LEVEL II

1

FRACTURE AND VISCOELASTIC CHARACTERISTICS OF THE HUMAN CERVICAL SPINE

KINEMATICS OF THE 3 ACTUATOR SYSTEM

Grant Number F49620-81-K-0010

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During the first five months of this research an analysis of the actuator kinematics and the load generation capabilities was performed. The Kinematic behavior of the Planar Motion Material Testing (PMMTA) actuators was analyzed using a computational algorithm written for a MINC-11-03 computer and a TK4010 plotting terminal. The analysis addressed; a)the range of motion of the test stage considering various angular orientations of the test stage for the most acceptable design, and b) the calculation of max loads in the vertical, horizontal and rotational directions for each position of the test stage.

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FIGURES AND TABLES

1.0 OBJECTIVES

The performance of the Planar Motion Material Testing Apparatus (PMMTA) will be studied in several steps. This report encompasses the first phase of these studies, an analysis of the actuator kinematics and the load generation capabilities.

The kinematic behavior of the PMMTA actuators was analyzed using a computational algorithm written for a MINC-11-03 computer and a TK4010 plotting terminal. This analysis addressed two specfic goals.

a) Determine the range of motion of the test stage considering various angular orientations of the test stage for the most acceptable design.

b) Calculate the maximum loads in the vertical, horizontal, and rotational directions for each position of the test stage.

2.0 BACKGROUND

2.1 Test Requirements

The minimum performance characteristics of the PMMTA are based on requirements for: the maximum load, the maximum rate of loading and the maximum sensitivity of the total system. This first study concentrates only on the load and kinematic envelopes. The computer and its peripheral data interface hardware should be the most critical components with respect to rate and sensitivity. These rate and sensitivity characteristics will be studied in conjunction with the development of the computing software in the next phase of the grant work.

The criteria for the approximate load requirements for the PMMTA may be obtained from the literature, Messerer (1880), Perry (1957), and Bell (1967). The results of their work are summarized in the book, Clinical Biomechanics of the Spine, by White and Panjabi (1978). A choice of requirements using this information should meet all of the test conditions of the current grant. In addition, testing of other portions of the human spine using higher loads than is needed for the cervical spine tests will be possible.

The compressive strength of the human vertebrae was investigated by these researchers. Summarizing the results for static or quasistatic loading, the maximum compressive strength of the vertebrae are:

a) Cervical (level C7)	< 2000 N (450 lbf)
b) Thoracic (level T11)	< 4000 N (900 lbf)
c) Lumbar (level L4)	< 8250 N (1860 lbf)

Under high speed dynamic tests the load needed to produce end plate or compressive failure is higher. Loads up to 13500 N (3030 lbf) have been recorded, Perry (1957).

An estimate of the magnitude of the shear type loads at failure may be obtained from the work of Weiss (1975). Loads of approximately 1000 N (224 lbf) applied directly through the facet articulations caused failure of the neutral arch (at the pedicles). The total shear required to induce failure of an intact FSU will of course be higher due to the additional load carried by the anterior elements of the FSU.

The amount of flexion-extension moment that the spine can support with deficit has not been studied as extensively as shear or axial loading. However, it is suggested that moments as small as [illegible] (11 in-lbf) can cause failure of spinal components, White and Panjabi (1978).

2.2 Test Hardware

The MOOG AO-85 servo actuator has been chosen for this project based on its performance features and reasonable availability. This actuator may be pivotted from either an upper or a lower pivot position

relative to the actuator body. Both mounting positions were considered in the initial part of this study. The piston area of the actuator is 1.1 in sq. which indicates a maximum force output of 3300 lbs at 3000 psi supply pressure. The piston stroke is 6 in.. The critical dimensions of this actuator and the pivot positions are shown in Figure 2.1. The geometry of the actuator was input point by point to the computer for the geometry calculations and plotting.

Installation Details

Individual installation drawings give details for each basic servoactuator size. Three standard sizes are available corresponding to piston areas of 1.1 in^2, 3.4 in^2 and 6.8 in^2. Standard stroke lengths for each size actuator are 1, 2, 4 and 6 inches. Actuators with total stroke up to 12 inches are available on special order.

Mounting

The servoactuator can be mounted in several ways. The lower face of the actuator body contains tapped holes for solid mounting. An alternate flange mounting is available for either the front or rear of the actuator. Actuators can also be supplied with a flange containing two horizontal pivot shafts for trunnion mounting. Heavy duty trunnions are available on special order.

Rod Attachment

Actuators are normally supplied with a female threaded rod (1.0 x 14 UNS-3B). An optional adapter is available to convert to a female 0.50 x 20 UNF-3B thread.

Side Loading

Moog Servoactuators have been designed to withstand heavy side loads and still give long, trouble free life. Nevertheless, actuator life will be improved by minimizing side loads. This can usually be done by careful alignment of the actuator mounting with the driven load.

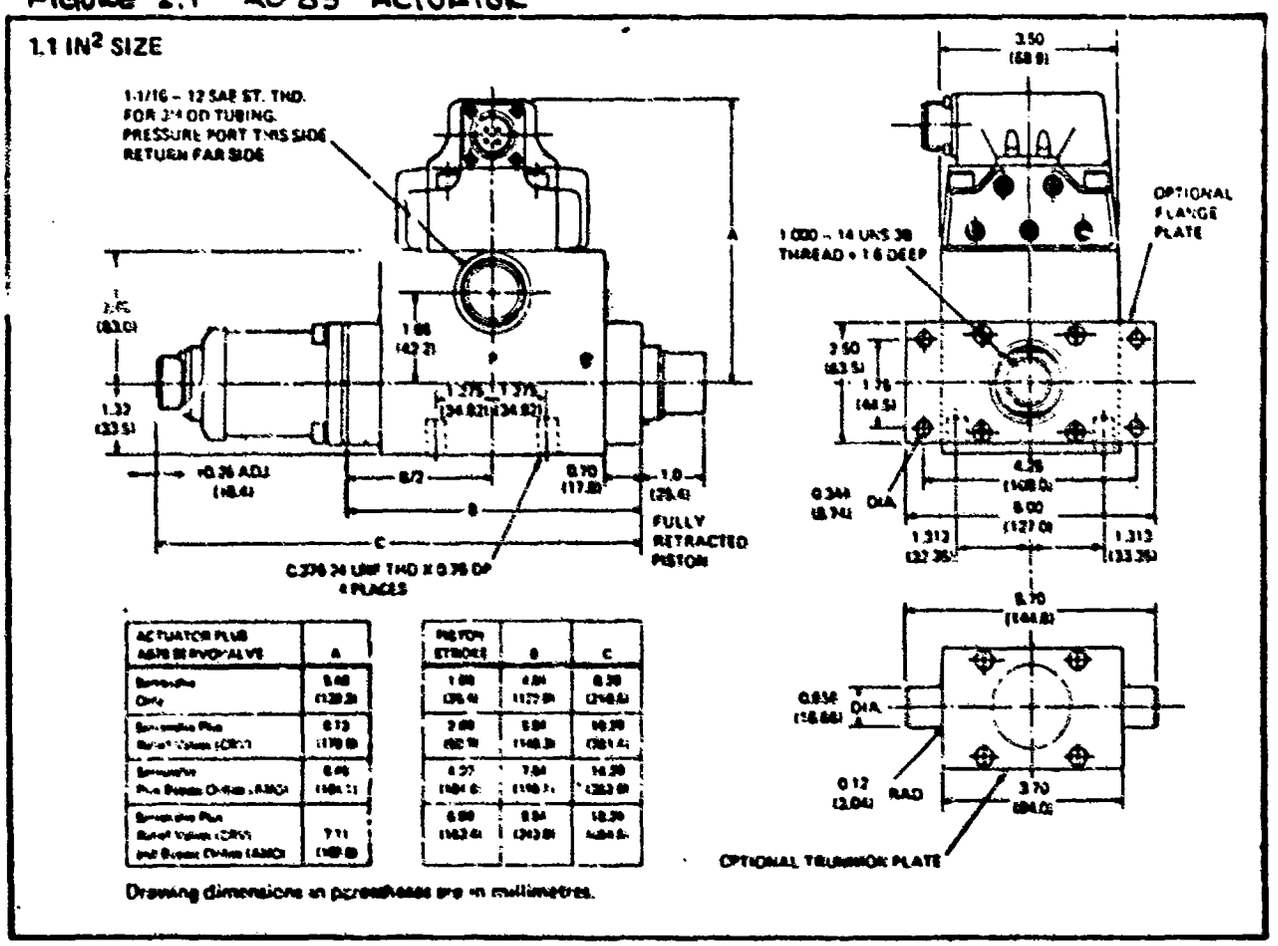
Fluid Supply Filtration

Good filtration will extend the life and improve the performance of A085 Servoactuators. The best arrangement is a full flow, non-bypass, pressure line filter immediately upstream of the servoactuator, and a low micron, full flow filter in the system return line.

The servoactuator can be provided with a Moog high pressure supply line filter connected with an adapter fitting directly to the pressure port. The filter is a 25 micrometre absolute, non-bypass, with replaceable element contained in a high pressure aluminum bowl. Both 10 gpm and 20 gpm filters are available.

Filter elements will withstand full 3000 psi differential pressure without collapse. An electrical dirt alarm can be supplied on special order.

FIGURE 2.1 - A0-85 ACTUATOR



Drawing dimensions in parentheses are in millimetres.

3.0 ANALYSIS METHODOLOGY

The kinematics of the three actuator system were analyzed using a MINC 11-03 computer. Four components of the PMMTA were considered in the study: the three actuators and the test stage which supports the inferior side of the test specimen. These components are indicated in Figure 3.1. The positions of the three actuators and the test stage, as they will be mounted in the loadframe, are defined by four geometric design parameters and the three piston lengths. The actuators are designated 1, 2, 3 from left to right. The four design parameters are:

1) S -- The length of the test stage. The height of the test stage above the point of connection to the extension from the actuators is 1.75 inches.

2) EXT -- The length of the extensions between the end of the actuators and the test stage.

3) X2 -- The horizontal position of the pivot point for actuator 2 relative to the actuator 1. (Actuator 1 is always drawn in position (0., 0.) and a reference set of axes are drawn through the pivot point).

4) X3 -- The horizontal position of the pivot point for actuator 3 relative to the actuator 1.

All three actuators pivot at the same vertical level, y=0. As indicated above, the effect of using the upper or the lower pivot position for each actuator was also investigated. With the actuators mounted from the upper pivot point, the actuators may be equally spaced along the X axis. To simplify calculations, the length of the test stage is the same as the distance between the second and third actuators. This means that the test stage should be exactly horizontal when the length of the second and third actuators are equal.

A piece of hardware is needed to join the actuator piston to the bearings of the test stage. This piece will extend the length of the piston and must be included in the analysis. The length of this extension between the test stage and an actuator is somewhat arbitrary. However, the extension should be long enough to permit each actuator the full 6 inches travel, if other factors permit this. An extension approximately 5-6 inches in length appears to provide reasonable clearance for most configurations. The extension requires approximately 1 inch of length to join the extension piece to the actuator piston. Excessively long extensions would imply unnecessary weight supported above the actuators, which should be avoided for dynamic considerations.

The kinematics program used to analyze these components permits definition of the desired motion in either of two ways. The input specifies either: a) the three piston lengths or b) the global coordinates and angle of a reference point on the test stage. With either of these sets of input data the program calculates the necessary kinematics and loads. Listings

of the main program along with the separate subroutines can be found in Appendix A.

For each set of calculations, four pieces of computer output may be produced, the plot of the actuator positions and three pages of printed data. A case number is included at the beginning of each line of results so that parameters corresponding to a specific calculation may be cross referenced on each page. A letter "P" adjacent to a case number indicates that the results of that case were included in the plot of the actuator position. Otherwise only the calculations were made and not included in a plot. All cases between a set of horizontal dashed lines consititute a motion sequence and were considered for one plot. Page one of the printed output presents the geometric information, piston lingths and test stage position. Page two presents the load calculations referenced to a point at the top center of the test stage, indicated by a "Δ" on the plots. Calculations referred to a set of axes drawn at this point, with the y axis perpendicular to the test stage and the x axis parallel to the test stage, are considered to be in the test stage or "local coordinates".

Page three presents the load calculations referenced to the pivot point of the first actuator, which is the origin of the axis system for the whole apparatus, or the "Global Coordinates".

For each case three load conditions were calculated. The positive or negative force limits of the actuator (3300 lbf) were used in three different configurations at each position to maximize the vertical, horizontal and moment directions. These various load conditions are indicated next to each case number either a V, H or M representing the maximum vertical, horizontal or moment case respectively.

The combination of piston force chosen here maximizes the three different load components for those positions of the apparatus in which the angle of the first actuator is $\leq 90^{\circ}$ and the angle of the third actuator is $\geq 90^{\circ}$ (the angle is measured counter clockwise positive from the X axis). For some of the extreme motions of the test stage, the relative positions of the actuators have changed enough to alter the effects of the generalized load cases. In these extreme cases, the same combination of piston forces may not actually maximize the intended load parameter.

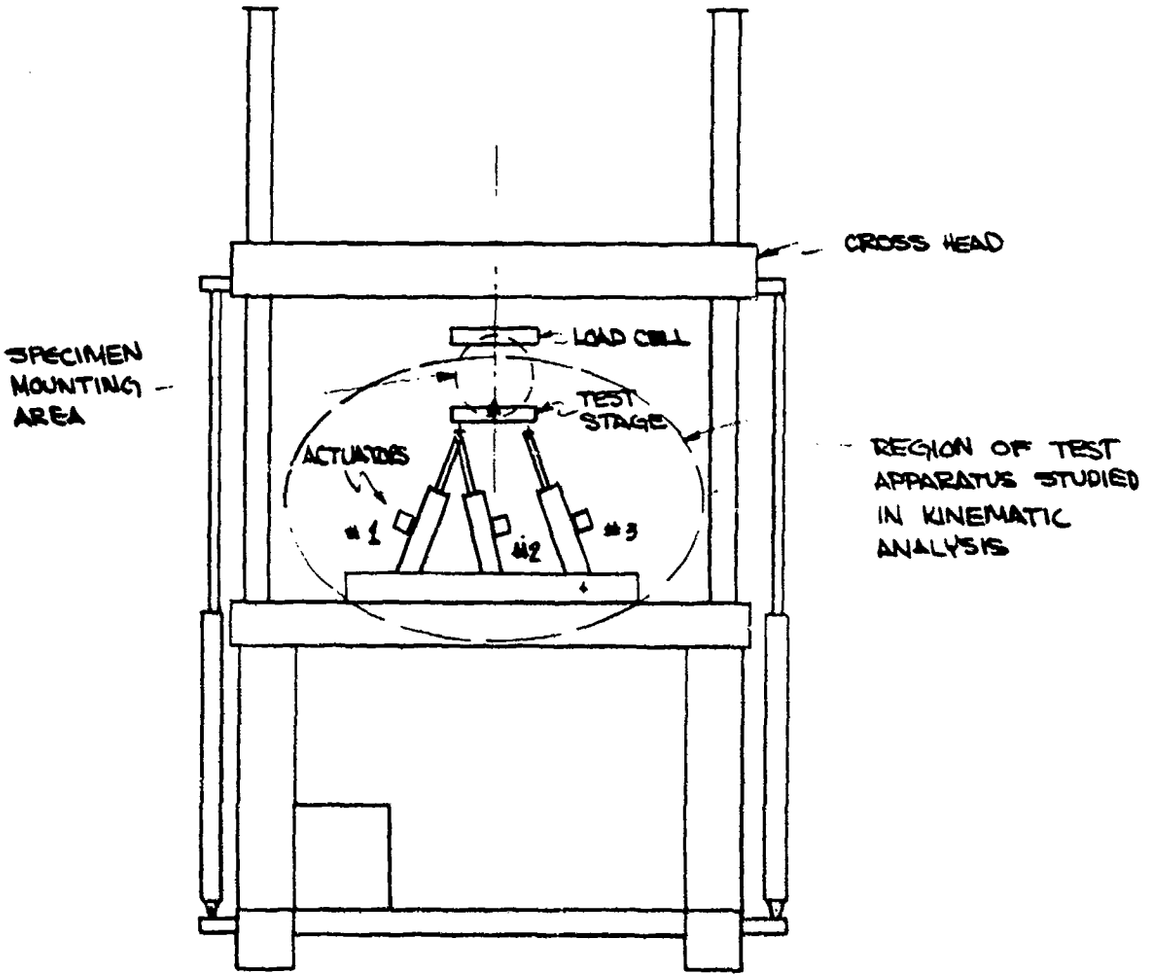


FIG. 3.1 - SKETCH OF LOAD FRAME SHOWING COMPONENTS STUDIED IN KINEMATIC STUDY

4.0 RESULTS

The results of the kinematic study were used to set the actuator design configurations as well as define the motion of the apparatus. The results of the study are in three areas:

a) Actuator configuration in the load frame
b) Envelope of motion for the apparatus
c) Loading capability

4.1 Actuator Configuration

The kinematics of two different pivot positions for the actuators was investigated. Figures 4.1 to 4.5 showrepresentative results for the actuator motions using the upper pivot point. These figures show displacement of the test stage with various length stages and a 5 inch extension on the actuators. For the upper pivot location, the test stage was required to be at least 5.0 in. to avoid interference. The figures show that the upper pivot position results in large motions of the body of the actuator. Figure 4.6 shows the motion of the system with the actuators mounted at the lower pivot point. Figures 4.3 and 4.6 show a comparison of the motion of the system with an upper versus the lower pivot point and a six inch test stage. The lower pivot point significantly reduces the motion of the actuators. Minimizing the motion of the actuators will minimize the inertial dynamics of the system thus optimizing the potential response characteristics.

4.2 Matrix Envelope

The test stage of the apparatus operates in a planar area, translatory vertically and horizontally with a positive (counter clockwise) or negative (clockwise) angle for the test stage surface. THe three factors that limit the motion envelope of the PMMTA are: 1) the piston lengths, (not to exceed six inches), 2) interference of the actuators with each other and 3) the third actuator should not go into a "snap-through" condition, a condition which exists when the test stage and the third actuator are aligned.

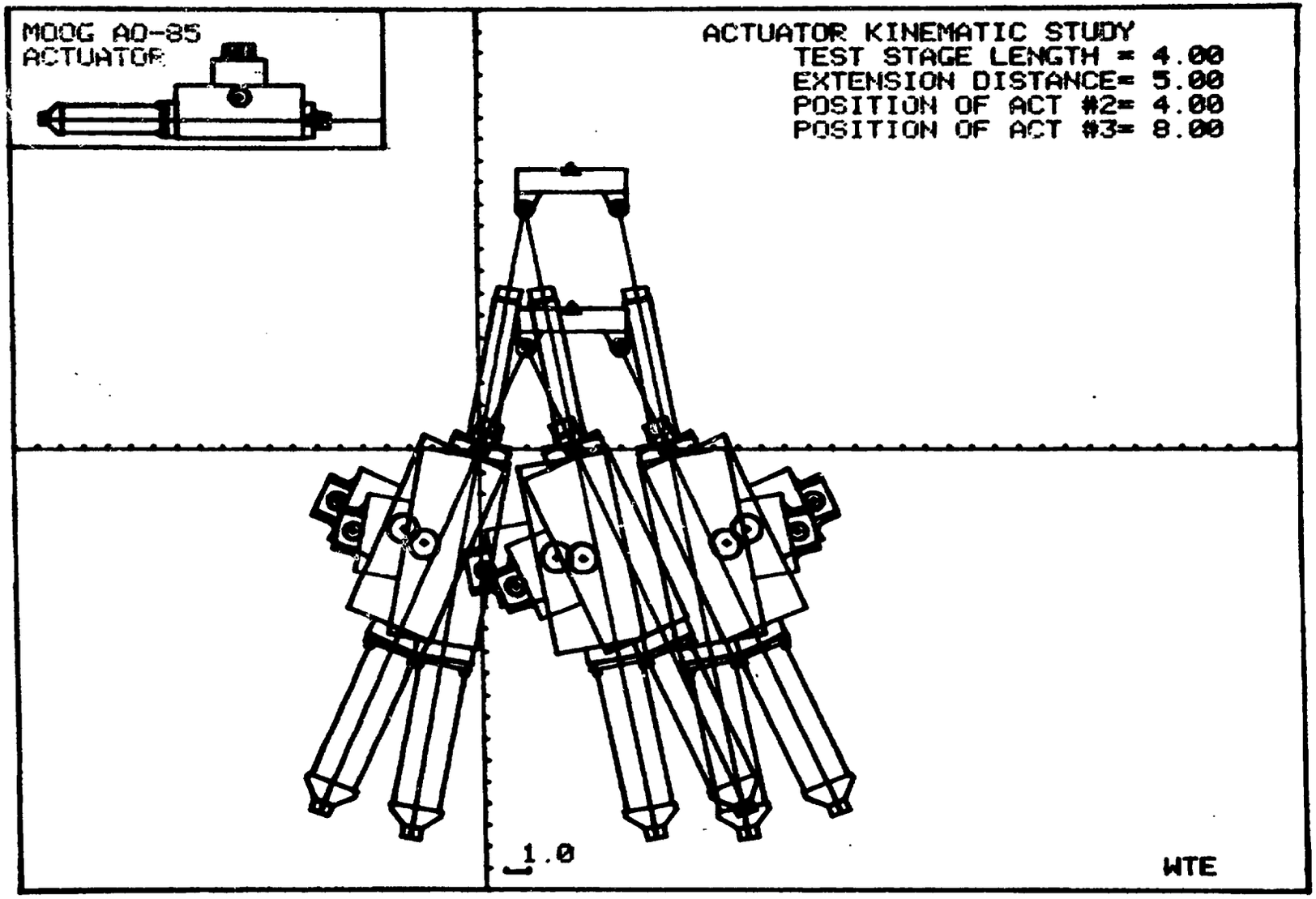


Fig. 4.1 Actuator Kinematics - Upper pivot, Test Stage Angle = 0°, Vertical Motion, Test Stage Length = 4 in.

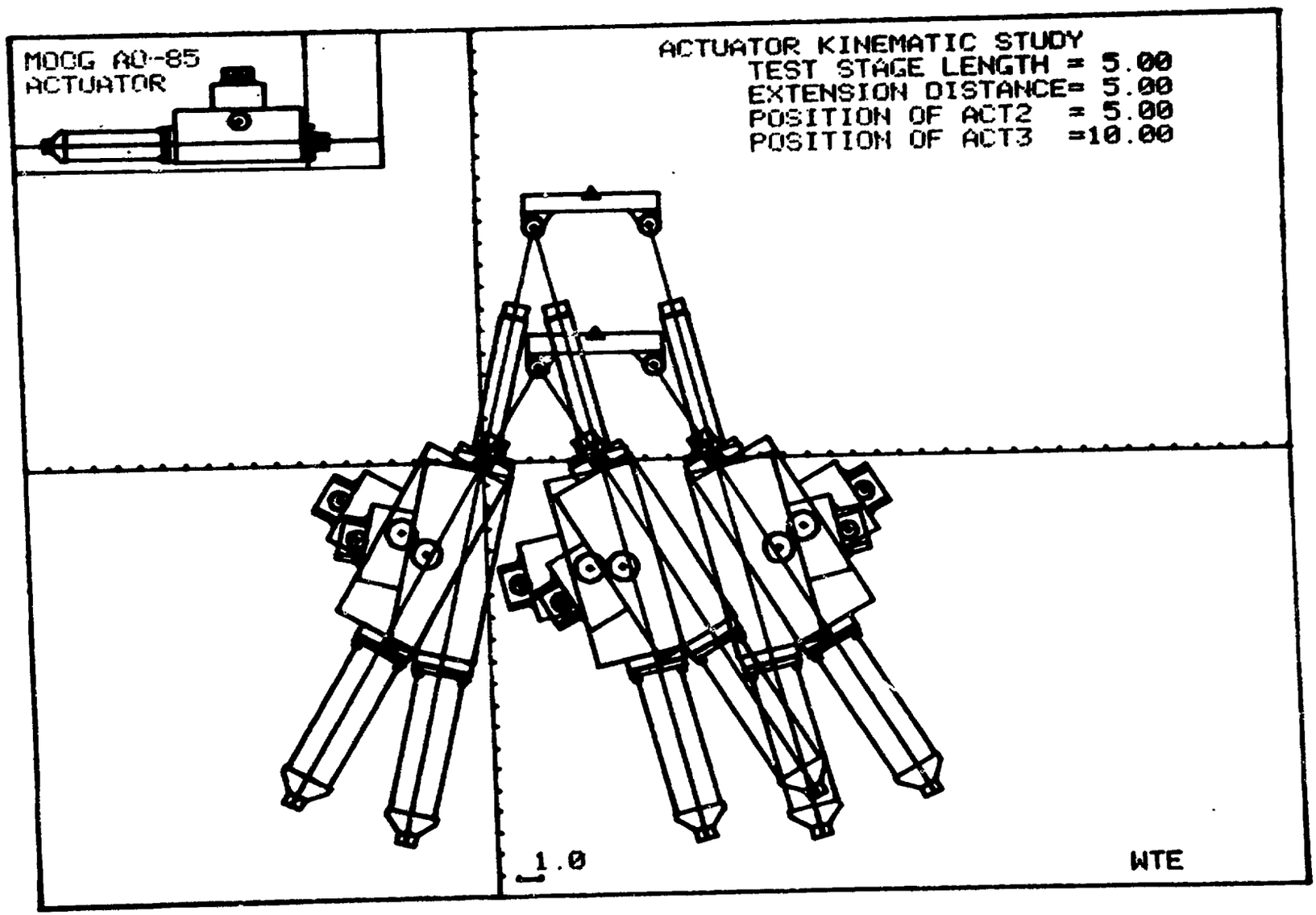


Fig. 4.2 Actuator Kinematics - Upper Pivot, Test Stage Angle = 0^{o}, Vertical Motion, Test Stage Length = 5 in.

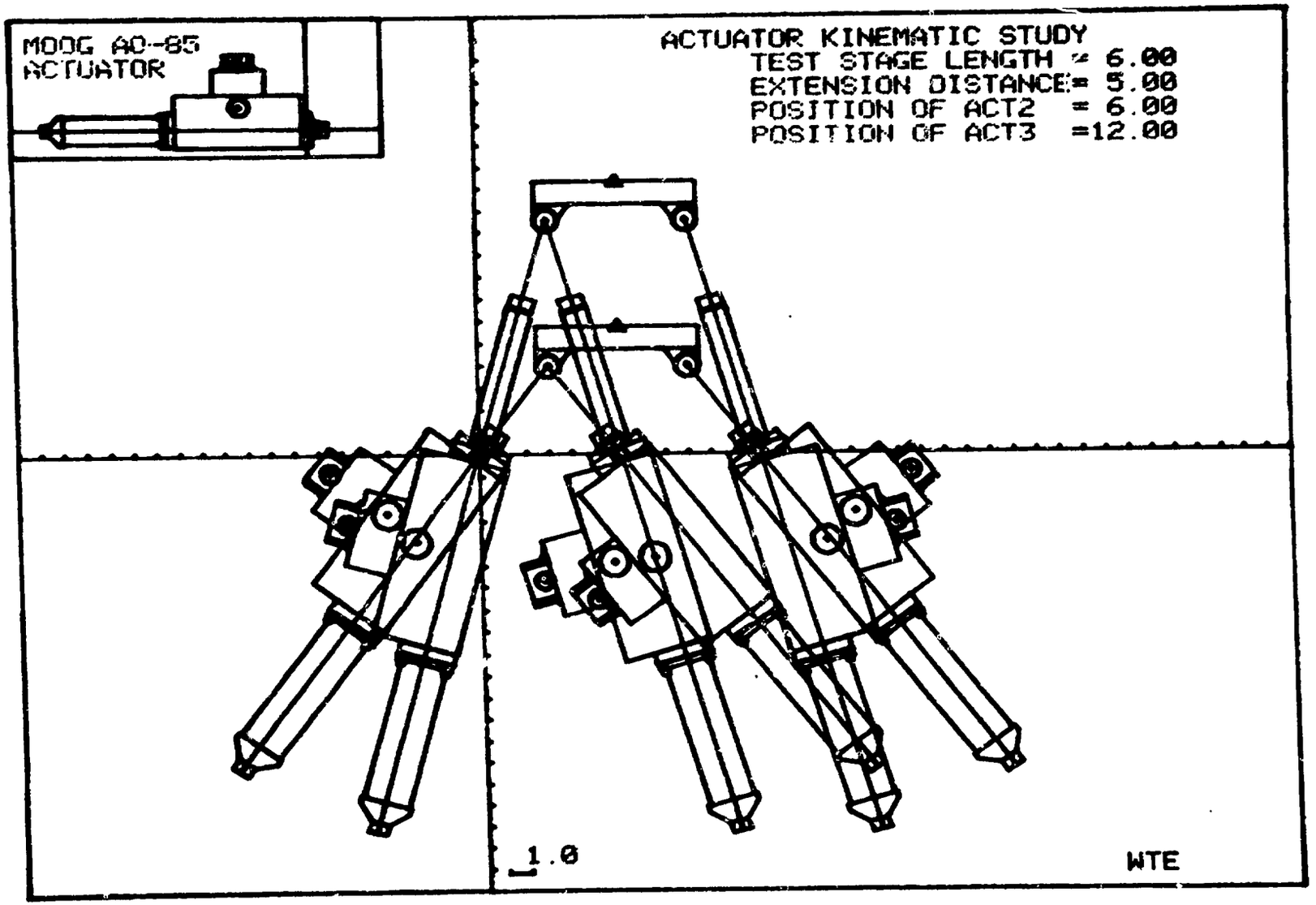


Fig. 4.3 Actuator Kinematics - Upper Pivot, Test Stage Angle = 0°, Vertical Motion, Test Stage Length = 6 in.

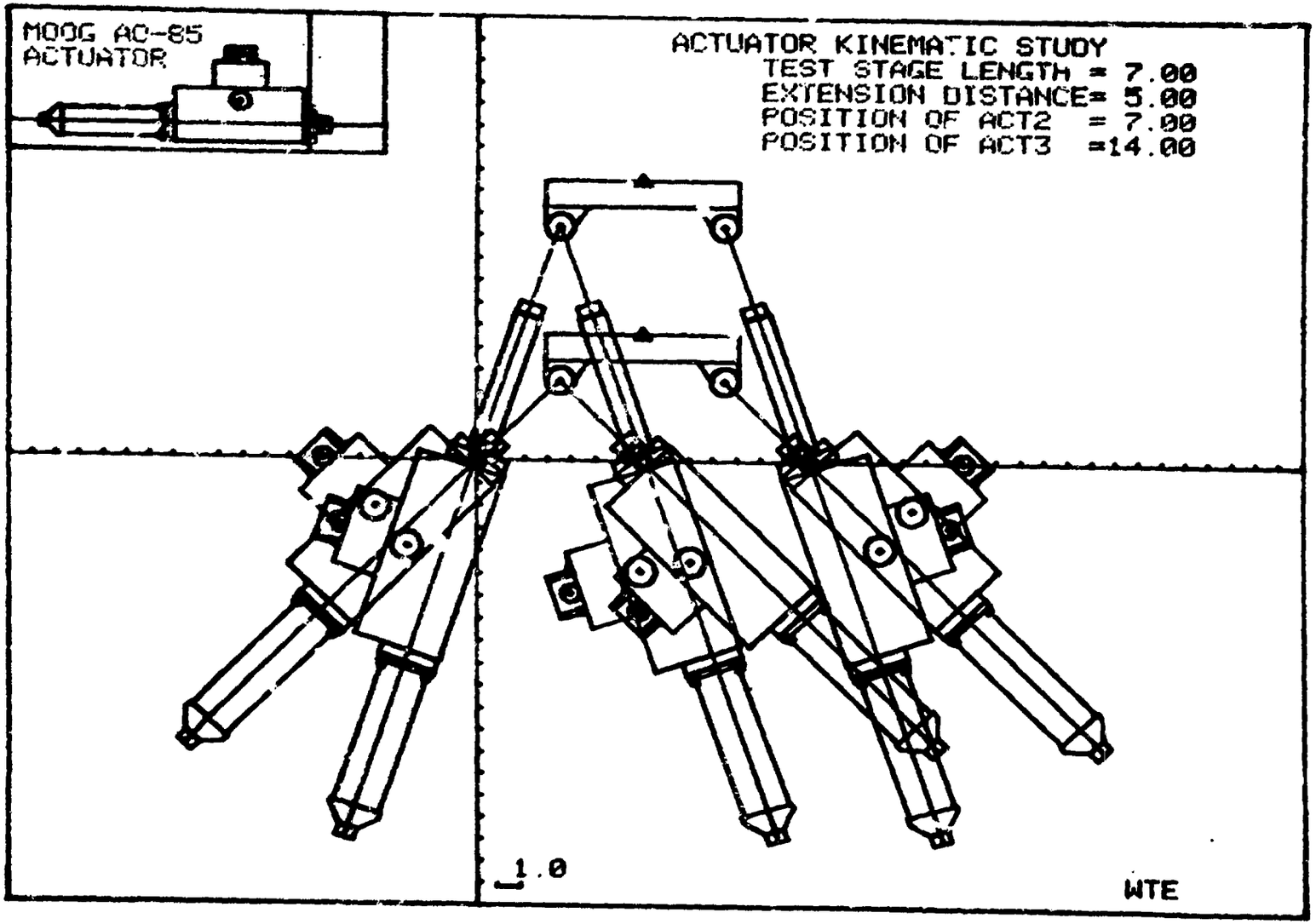


Fig. 4.6 Actuator Kinematics - Upper Pivot, Test Stage Angle = 0°, Vertical Motion, Test Stage Length = 7 in.

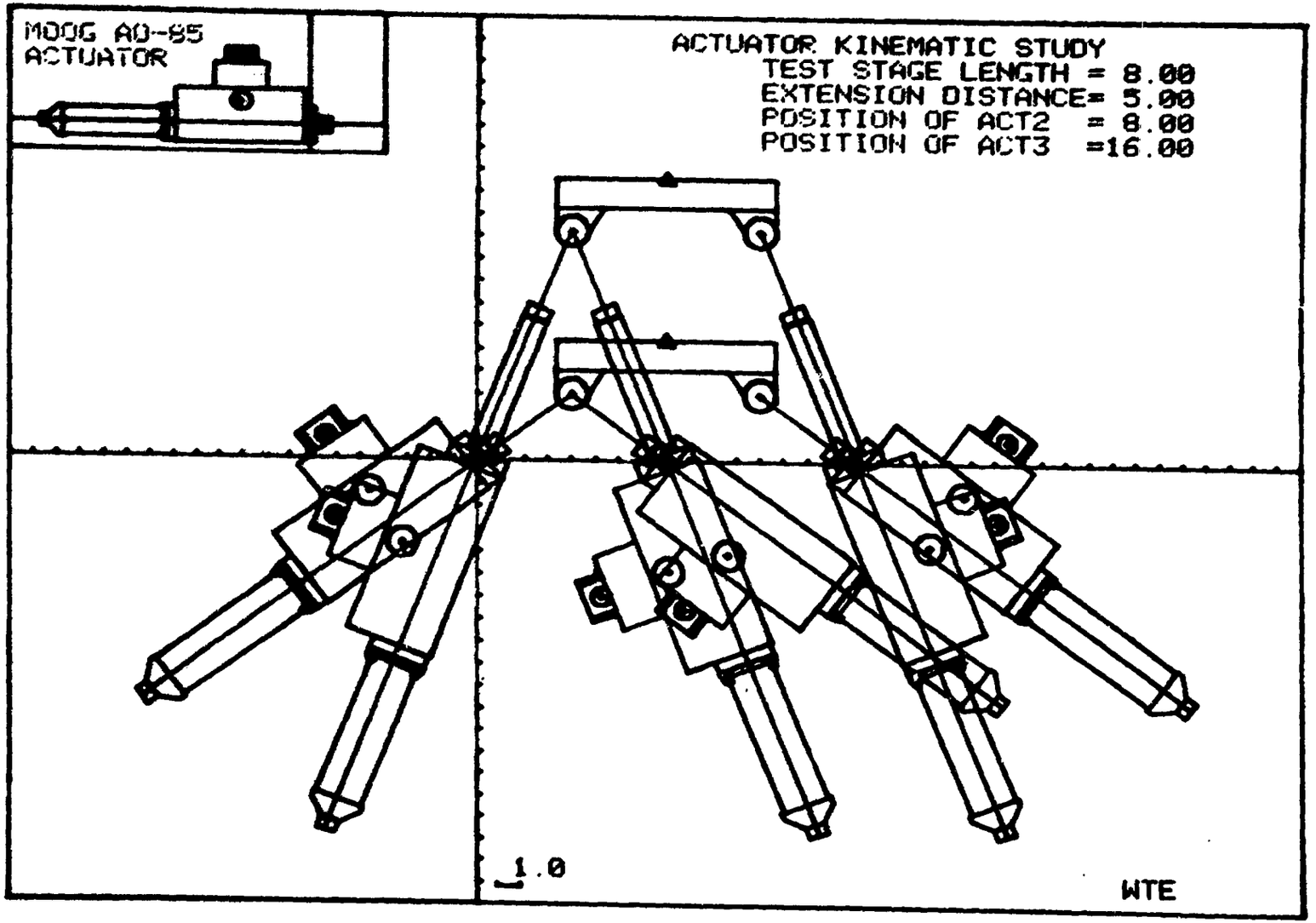


Fig. 4.5 Actuator Kinematics - Upper Pivot, Test Stage Angle = 0°, Vertical Motion, Test Stage Length = 8 in.

Considering these factors, the envelopes of motion for the test stage were determined. The maximum and minimum vertical and horizontal positions of the system with the test stage at 0° angle were determined. The point (9, 17.6) is the center or mean between these four extreme points. The range of motion from this point in the direction of the extremes was determined for various angles of the test stage. The test stage angles varied from -50° to +50°. Figures 4.6 to 4.11 show the vertical and horizontal extreme positions for the test stage at 0° and 30°. The calculations for the kinematic positions and maximum forces on the test stage for each position are presented in Tables 4.1-4.6. Appendix B contains the figures for the remaining angles up to plus and minus 50°.

4.3 Load Sensitivity

At each maximum and minimum position, for a particular angle, the minimum forces on the test stage and specimen were determined.

Tables I and II indicate the maximum forces and moments along the horizontal and vertical axis at various angles that the PMMTA can generate. Shown below is a comparison of the test requirements from Section 2.1 and the PMMTA capacity.

	Test Requirement	PMMTA Capacity
Horizontal	2500 lbf	2200-8200 lbf
Vertical	3030 lbf	4200-9500 lbf
Moment	71 in-lbf	11-26,000 in-lbf

The requirements for the test specimens are well within the capacity of the PMMTA.

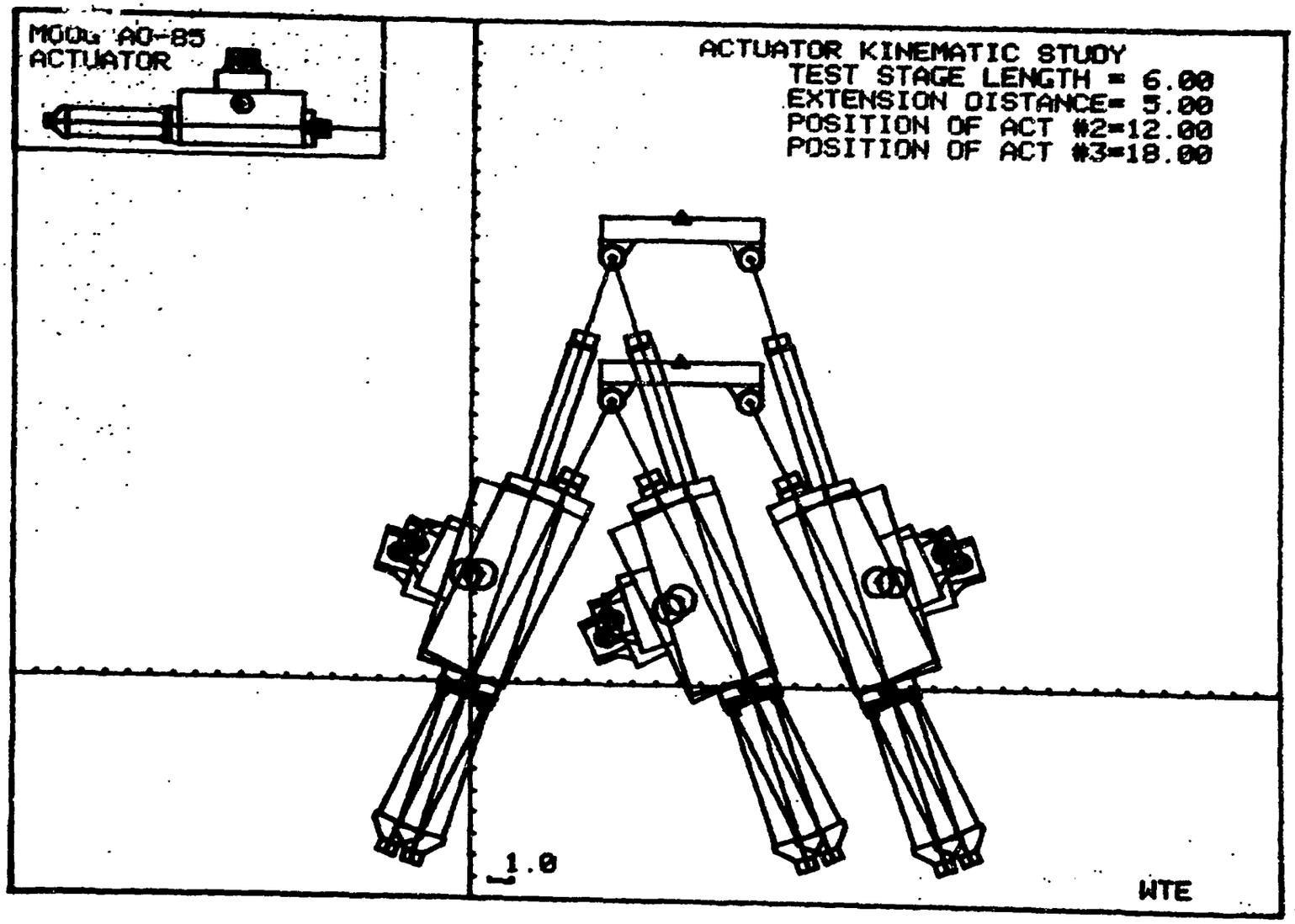


Fig. 4.6 Actuator Kinematics - Lower Pivot, Test Stage Angle = 0°, Vertical Motion Along the Center of the Motion Envelope

TABLE 4.1a
(SEE FIG.4.6)

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: M030 - A085 - 6 IN STROKE

DATE : 30-JUL-91

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 5.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	6.0000	6.0000	6.0000	9.0000	19.2235	0.0000	9.0000	20.9755
P 2	0.0000	0.0000	0.0000	9.0000	12.9039	-0.0000	9.0000	14.5539

TABLE 4.1-6

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 30-JUL-81

ACTUATOR: MOOG - AO85 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX: (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	0.0	6300.3	-983.1	3150.2	983.1	-9450.5	11170.9
H	1885.2	-0.0	983.1	-3150.2	-2945.4	3150.2	4289.1
M	0.0	6300.3	983.1	-3150.2	-983.1	-3150.2	25830.9
2 V	-0.0	5576.4	-1400.3	2988.2	1400.3	-8964.5	11415.0
H	2800.6	0.0	1400.3	-2988.2	-4200.9	2988.2	1513.0
M	-0.0	5576.4	1400.3	-2988.2	-1400.3	-2988.2	24443.1

TABLE 4.1-C

FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 30-JUL-81
ACTUATOR: MOCC - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 5.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	0.0	6300.3	-983.1	3150.2	983.1	-9450.5	11170.9
H	1966.2	0.0	983.1	-3150.2	-2949.4	3150.2	4289.1
M	0.0	6300.3	983.1	-3150.2	-983.1	-3150.2	23630.9
2 V	-0.0	5976.4	-1400.3	2988.2	1400.3	-8964.5	11415.0
H	2800.6	0.0	1400.3	-2988.2	-4200.8	2988.2	1613.0
M	-0.0	5976.4	1400.3	-2988.2	-1400.3	-2988.2	24443.1

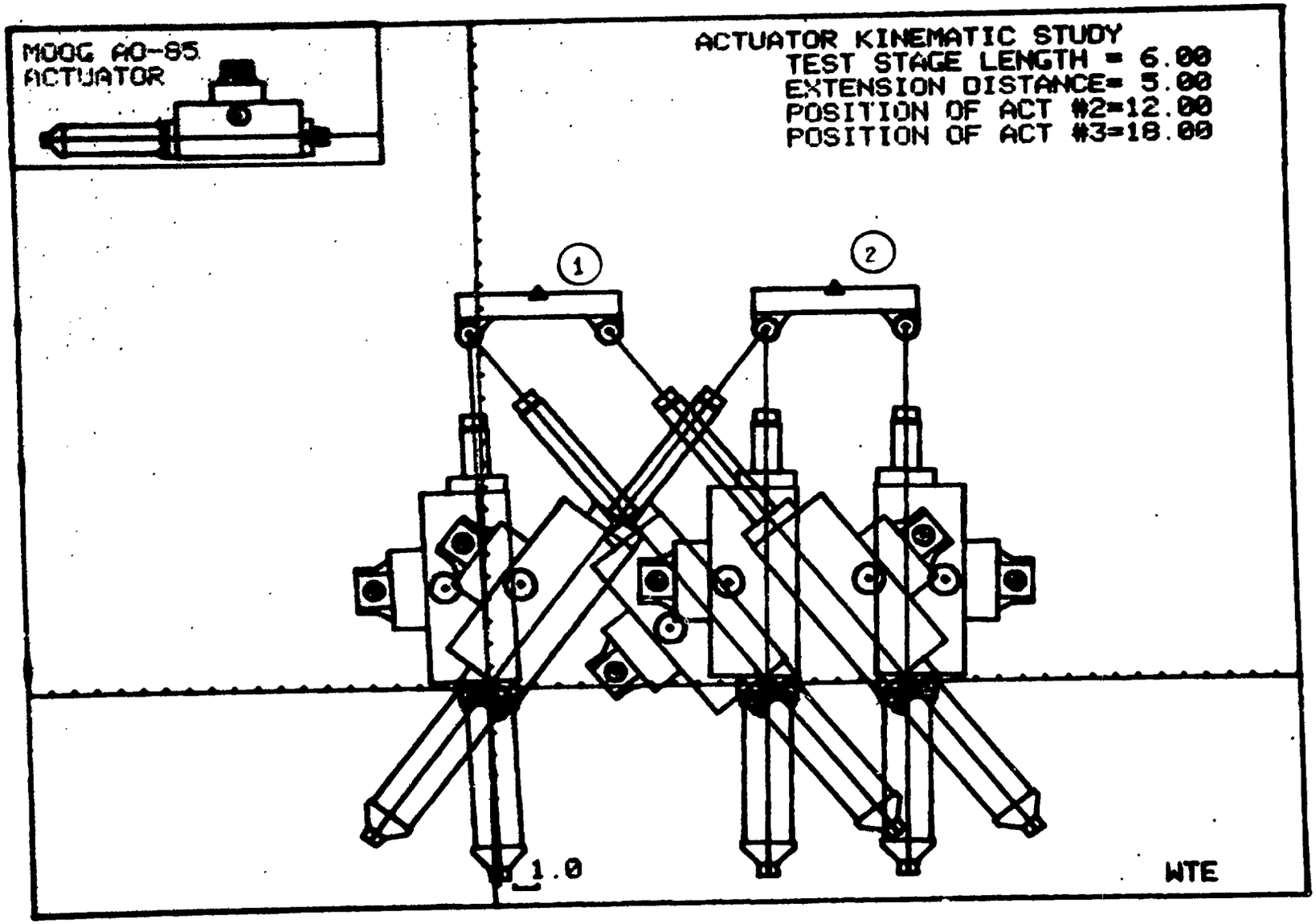


Fig. 4.7 Actuator Kinematics - Lower Pivot, Test Stage Angle = 0^{o}, Horizontal Motion Along the Center of the Motion Envelope

TABLE 4.2-a
(SEE FIG 4.7)

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: MOOG - A085 - 6 IN STROKE

DATE : 05-AUG-81

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	1.7148	5.9780	5.9780	2.6100	15.8500	-0.0000	2.6100	17.6000
P 2	5.9903	1.7153	1.7153	15.4100	15.8500	0.0000	15.4100	17.6000

TABLE 4.2-6

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 05-AUG-81
ACTUATOR: MOOR - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-2113.5	5898.9	-2032.4	2599.9	4145.9	-8498.8	17152.3
H	1951.2	699.1	2032.4	-2599.9	-3883.5	1900.8	2925.8
M	-2113.5	5898.9	2032.4	-2599.9	81.2	-3299.0	25638.5
2 V	2119.7	5897.2	85.3	3298.9	-2205.1	-9196.1	3936.1
H	1949.1	-700.6	-85.3	-3298.9	-1863.7	3999.5	4533.4
M	2119.7	5897.2	-85.3	-3298.9	-2034.4	-2598.3	24028.1

TABLE 4.2-C

FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 05-AUG-81
ACTUATOR: HOOR - AOOS - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-2113.5	5050.9	-2032.4	2599.9	4145.9	-8498.8	17152.3
H	1951.2	899.1	2032.4	-2599.9	-3983.5	1900.8	2925.8
M	-2113.5	5050.9	2032.4	-2599.9	81.2	-3299.0	25630.5
2 V	2119.7	5057.2	85.3	3298.9	-2205.1	-9196.1	3536.1
H	1949.1	-700.6	-85.3	-3298.9	-1863.7	3999.5	4533.4
M	2119.7	5057.2	-85.3	-3298.9	-2034.4	-2598.3	24028.1

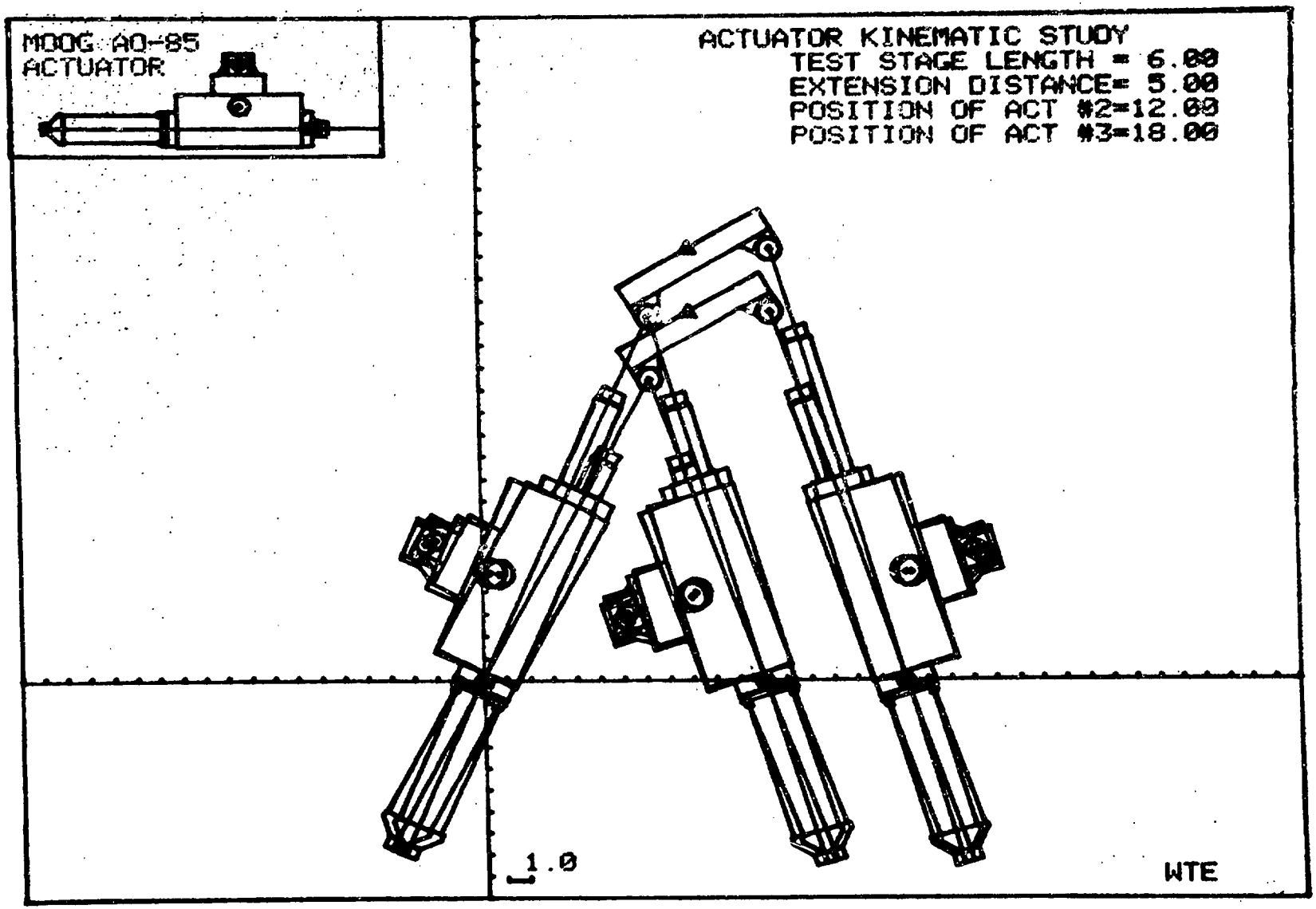


Fig. 4.8 Actuator Kinematics - Lower Pivot, Test Stage Angle = 30°, Vertical Motion Along the Center of the Motion Envelope

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: MOOG - A065 - 6 IN STROKE

DATE : 03-AUG-81

TABLE 4.3-a
(SEE FIG. 4.8)

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STB POS X	STB POS Y
P 1	3.8984	2.8136	5.9208	9.8750	17.7845	0.5236	9.0000	18.3000
P 2	1.1827	0.1477	3.2463	9.8750	14.9845	0.5236	9.0000	16.5000

TABLE 4.3-6

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 03-AUG-01

ACTUATOR: MOOG - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	3461.0	5140.4	798.8	3201.9	-4259.8	-8342.3	-1636.9
H	1883.8	-1288.3	-798.8	-3201.9	-1085.0	4470.2	3901.8
M	3461.0	5140.4	-798.8	-3201.9	-2862.2	-1538.6	20388.0
2 V	3421.8	4874.1	835.9	3234.2	-4077.7	-8208.2	-1916.2
H	2156.8	-1511.2	-835.9	-3234.2	-1540.9	4745.4	2472.3
M	3421.8	4874.1	-835.9	-3234.2	-2765.9	-1739.9	15784.4

FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 03-AUG-01 TABLE 4.3-c

ACTUATOR: MOOG - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	427.1	6182.3	-909.2	3172.3	482.1	-8354.5	-1838.9
H	2265.6	-156.5	909.2	-3172.3	-3174.8	3328.8	3901.8
M	427.1	6182.3	909.2	-3172.3	-1338.3	-3010.0	20388.0
2 V	476.3	6018.6	-1049.0	3128.8	572.7	-8147.4	-1916.2
H	2638.1	-210.4	1048.0	-3128.8	-3707.1	3338.2	2472.3
M	476.3	6018.6	1049.0	-3128.8	-1525.4	-2889.8	19784.4

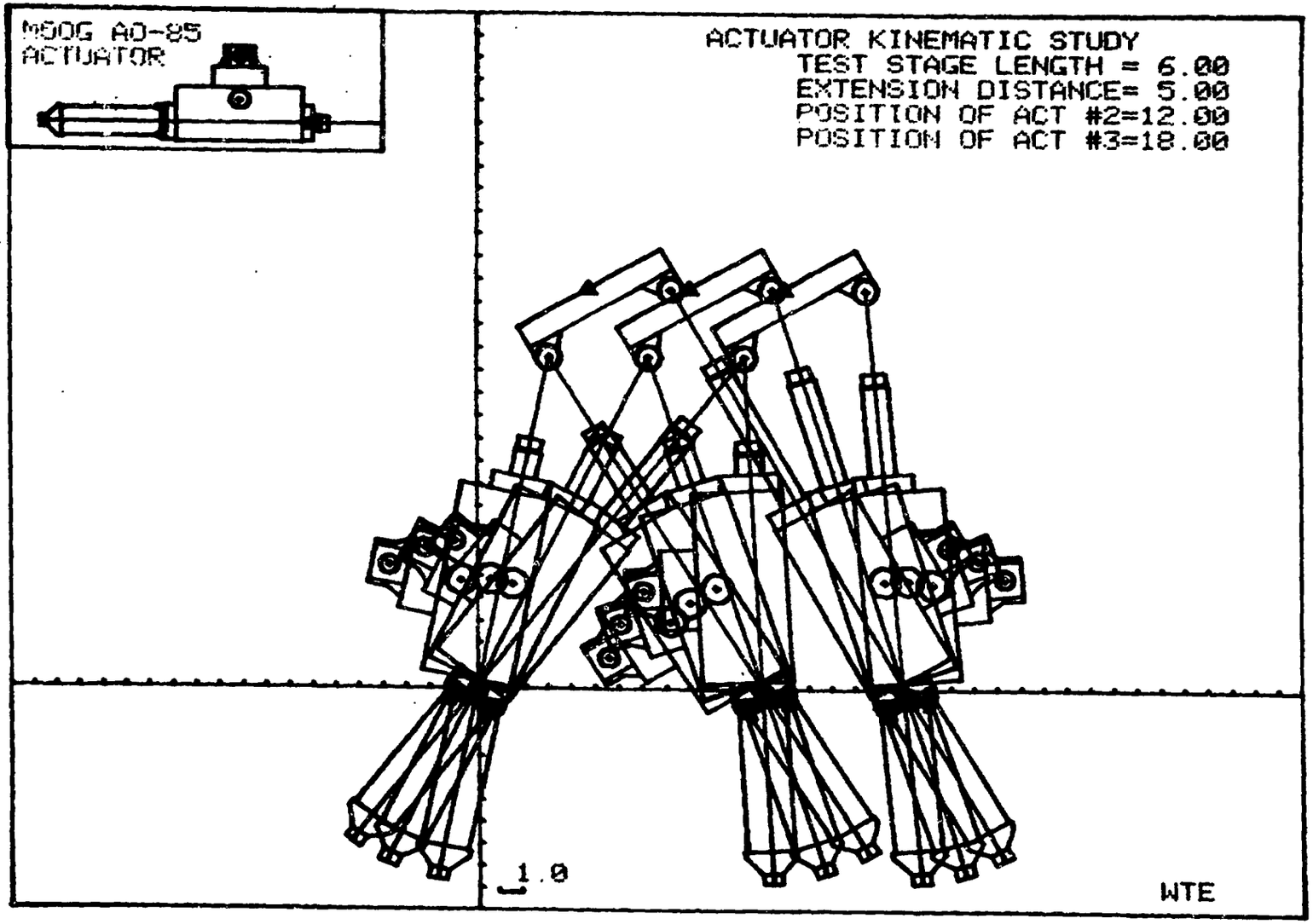
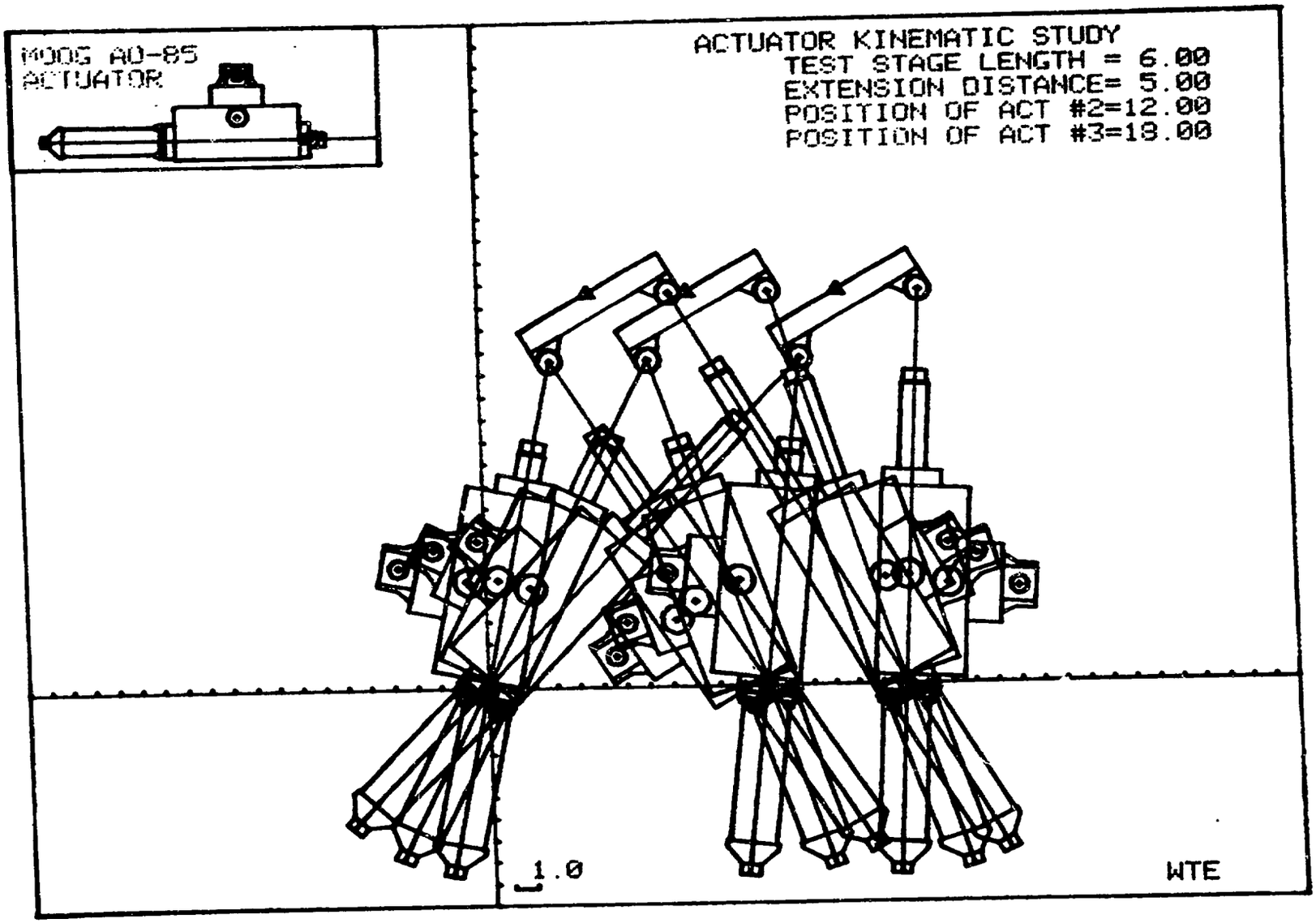


Fig. 4.9 Actuator Kinematics - Lower Pivot, Test Stage Angle = 30°, Horizontal Motion Along the Center of the Motion Envelope

20° MIN FOR PLS
BUT INTERFERENCE.



KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: MCCG - AC85 - 6 IN STROKE

DATE : 30-JUL-81

TABLE 4.4-a
(SEE FIG. 4.9)

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	0.7553	2.9837	5.9797	5.6250	16.0845	0.5236	4.7500	17.6000
P 2	2.1591	1.1902	4.2926	9.8750	16.0845	0.5236	9.0000	17.6000
P 3	4.2657	0.4624	3.5108	13.8750	16.0845	0.5236	13.0000	17.6000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 30-JUL-81 TABLE 4.4-b

ACTUATOR: MOOG - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	2104.1	5761.7	53.3	3289.6	-2157.4	-9081.2	3610.8
H	2288.6	-835.8	-53.3	-3298.6	-2235.3	4135.3	3479.7
M	2104.1	5761.7	-53.3	-3298.6	-2050.8	-2462.1	23594.9
2 V	3441.6	5047.8	717.2	3221.1	-4158.8	-8268.9	-1757.9
H	2063.1	-1406.6	-717.2	-3221.1	-1346.0	4627.8	3088.1
M	3441.6	5047.8	-717.2	-3221.1	-2724.5	-1626.7	20039.0
3 V	4555.9	4187.7	1396.6	2985.9	-5856.5	-7177.6	-5830.6
H	1547.0	-1684.5	-1396.6	-2985.9	-150.4	4874.4	3853.0
M	4555.9	4187.7	-1396.6	-2985.9	-3163.3	-1197.9	15956.9

FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 30-JUL-81

TABLE 4.4-c

ACTUATOR: MOOG - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR		FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1	V	-1058.6	6041.8	-1603.6	2884.2	2662.2	-8926.0	3610.8
	H	2399.8	420.5	1603.6	-2884.2	-4003.4	2463.7	3479.7
	M	-1058.6	6041.8	1603.6	-2884.2	-545.0	-3157.6	23594.9
2	V	456.6	6092.3	-989.5	3148.2	532.8	-9240.5	-1797.9
	H	2490.0	-186.6	989.5	-3148.2	-3479.5	3334.8	3082.1
	M	456.6	6092.3	989.5	-3148.2	-1446.1	-2944.2	20039.0
3	V	1855.2	5906.6	-285.5	3287.6	-1569.7	-9194.2	-6830.6
	H	2182.0	-685.3	285.5	-3287.6	-2467.5	3973.0	3653.0
	M	1855.2	5906.6	285.5	-3287.6	-2140.6	-2618.6	15999.9

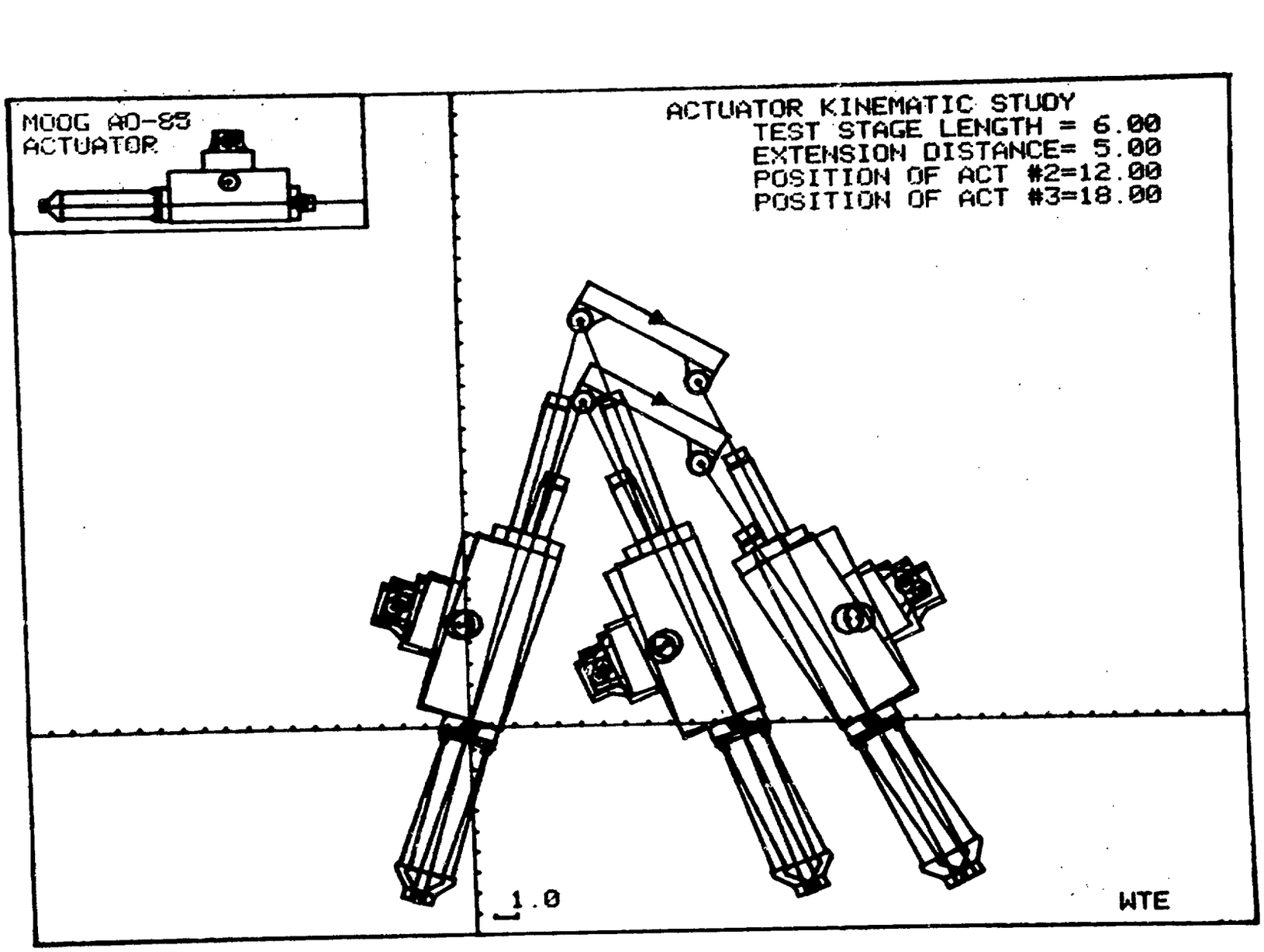


Fig. 4.10 Actuator Kinematics - Lower Pivot, Test Stage Angle = 30°, Vertical Motion Along the Center of the Motion Envelope

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: MOOG - A085 - 6 IN STROKE

DATE : 03-AUG-81

TABLE 4.5-a
(SEE FIG. 4.10)

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	5.6326	5.9177	3.4229	8.1250	17.4845	-0.5236	9.0000	19.0000
P 2	2.0190	2.3868	0.0521	8.1250	13.6845	-0.5236	9.0000	15.2000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 03-AUG-81 TABLE 4.5-6

ACTUATOR: MRRS - ARRS - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-3269.4	5377.7	-2085.8	1917.4	5855.2	-7285.0	20802.5
H	1858.6	1032.7	2085.8	-1917.4	-4384.5	884.7	1177.4
M	-3269.4	5377.7	2085.8	-1917.4	583.6	-3460.3	22906.4
2 V	-3211.6	5231.8	-2082.0	1607.6	6083.5	-6839.4	21536.3
H	2085.6	1268.0	2082.0	-1607.6	-4947.5	339.6	-31.6
M	-3211.6	5231.8	2082.0	-1607.6	329.6	-3624.2	21094.9

FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 03-AUG-81

TABLE 4.5-c

ACTUATOR: H800 - A005 - 5 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 8.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-142.8	6291.9	-1367.3	3003.4	1505.8	-9285.3	20802.5
H	1967.4	45.0	1367.3	-3003.4	-3354.7	2858.4	1177.4
M	-142.8	6291.9	1367.3	-3003.4	-1224.7	-3288.5	22806.4
2 V	-165.4	6136.6	-1892.1	2833.2	1857.5	-8969.8	21536.3
H	2422.8	85.3	1892.1	-2833.2	-4114.9	2787.9	-31.8
M	-165.4	6136.6	1892.1	-2833.2	-1528.7	-3303.5	21054.9

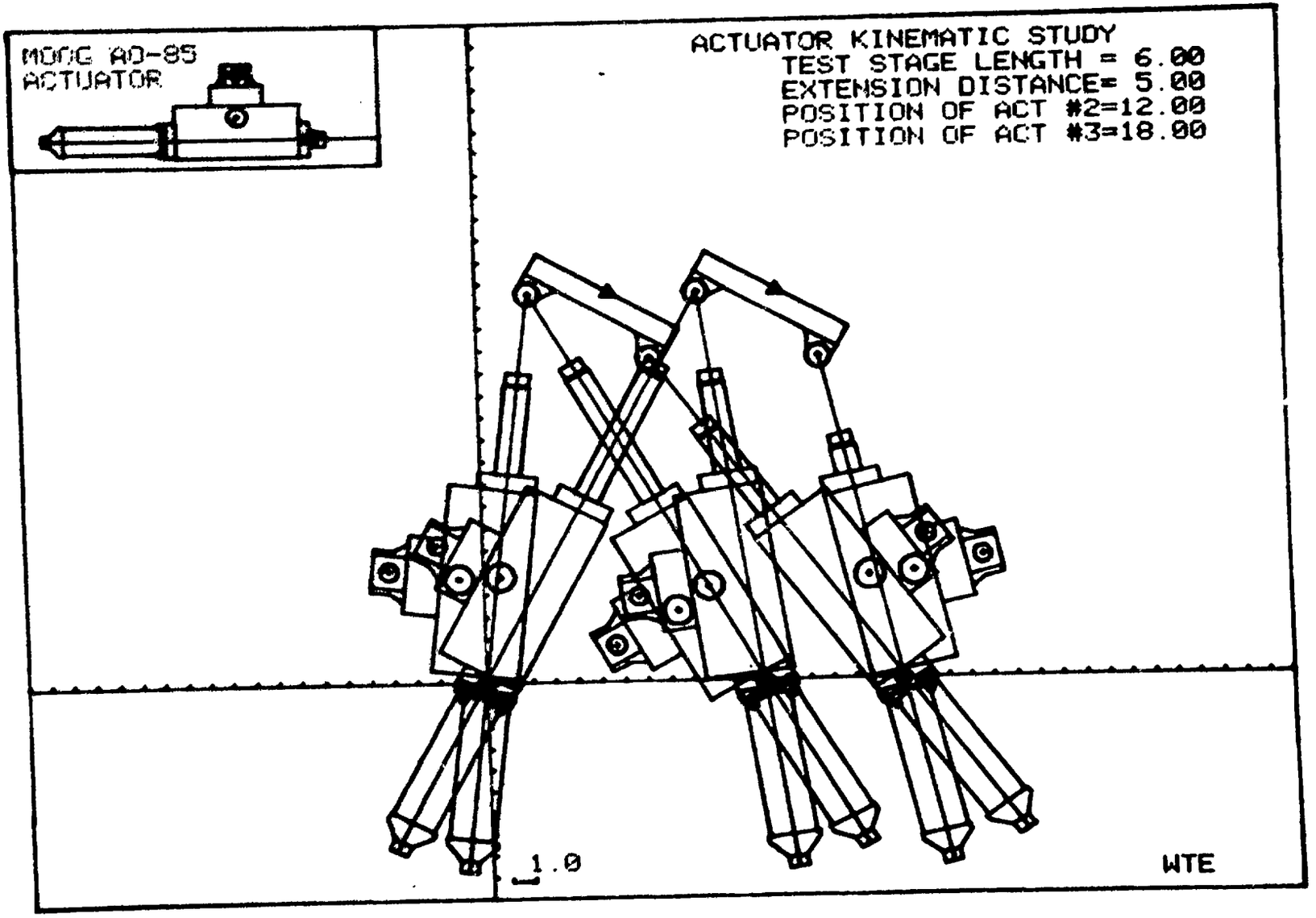


Fig. 4.11 Actuator Kinematics - Lower Pivot, Test Stage Angle = -30°, Horizontal Motion Along the Center of the Motion Envelope

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: MOOS - AOOS - 6 IN STROKE

DATE : 03-AUG-81

TABLE 4.6-a
(SEE FIG. 4.11)

/CTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	3.5849	5.9770	3.8760	4.8250	16.0845	-0.5236	5.7000	17.8000
P 2	5.8594	3.6175	0.8081	12.1250	16.0843	-0.5236	13.0000	17.8000

TABLE 4.6-6

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: MOOS - AOOS - 0 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-4108.4	4739.0	-3013.5	1344.8	7122.0	-6083.8	22645.9
H	1352.7	1346.1	3013.5	-1344.8	-4366.2	-1.3	81.9
M	-4108.4	4739.0	3013.5	-1344.8	1094.9	-3394.1	20167.5
2 V	-2121.3	5899.0	-2236.4	2426.7	4357.7	-8325.7	18043.1
H	1942.6	698.6	2236.4	-2426.7	-4176.9	1728.1	2062.5
M	-2121.3	5899.0	2236.4	-2426.7	-115.1	-3472.4	24775.7

FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 03-AUG-81 TABLE 4.6-C

ACTUATOR: MOOG - ADBS - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-1188.5	6158.3	-1837.4	2671.4	3125.9	-8829.7	22845.9
H	2017.7	389.4	1837.4	-2671.4	-3855.1	2282.0	81.8
R	-1188.5	6158.3	1837.4	-2671.4	-748.9	-3486.8	20167.5
2 V	1112.4	6169.4	-723.4	3219.7	-389.0	-8389.1	18043.1
H	2031.6	-386.3	723.4	-3219.7	-2735.0	3586.0	2062.5
R	1112.4	6169.4	723.4	-3219.7	-1835.8	-2949.6	24775.7

TABLE I

FORCE RANGES AT MAXIMUM AND MINIMUM POSITIONS FOR EACH ANGLE ALONG THE HORIZONTAL AXIS

ANGLE (deg)	HORIZONTAL (lbf)	VERTICAL (lbf)	MOMENTS (in-lbf)
+50°	6500 - 7800	5000 - 6500	14,000
-50°	7700 - 8200	4200 - 5100	24-26,000
+40°	4400 - 6800	6200 - 8100	13-19,000
-40°	6200 - 7800	5200 - 7000	21-23,000
+30°	2200 - 5900	7200 - 9100	16-24,000
-30°	4400 - 7100	6100 - 8300	23-25,000
+20°	2900 - 3000	4400 - 9300	17-26,000
-20°	3500 - 6200	7000 - 9100	22-26,000
+10°	3500 - 4000	8500 - 9100	21-26,000
-10°	2700 - 5200	7800 - 9400	24-26,000
0°	2200 - 4100	8500 - 9200	24-26,000

TABLE II

FORCE RANGES AT MAXIMUM AND MINIMUM POSITIONS FOR EACH ANGLE ALONG THE VERTICAL AXIS

ANGLE (lbf)	HORIZONTAL (lbf)	VERTICAL (lbf)	MOMENT (in-lbf)
+50°	6900-7000	6000	11-12,000
-50°	8100	4500	25,000
+40°	5600-5700	7200-7300	16,000
-40°	7200	5700-6000	23,000
+30°	4100-4200	8200-8300	20,000
-30°	3300-4100	8900-9300	21-23,000
+20°	2500-2600	8800-9100	22-23,000
-20°	4400-4800	7800-8300	23-25,000
+10°	2400-3300	9100-9400	24-26,000
-10°	3500-4500	8500-9100	24-26,000
0°	2900-4200	8900-9500	24-26,000

5.0 DISCUSSION: Selection of Design Parameters

To optimize the response of the system a pivot point that minimizes gross actuator motion is required. The results indicated that the lower pivot point is the best choice to meet this requirement. Therefore, the apparatus design will incorporate the actuators mounted at the lower pivot point.

A set of ranges of maximum and minimum motion was established for the test stage positioned at positive angles. A second set was determined for the negative angles. These results were combined into a single set of envelopes by using the more conservative extreme positions from the two sets of calculations at each magnitude (absolute value) of test stage angle. Figure 5.1 shows the range of motion for the absolute value of test stage angle. In the first quadrant the actual boundary for 0° angle of the stage is shown. This curvature of the envelope was found to be similar for all of the envelopes.

In order to simplify the boundary conditions, a conservative, linear approximation was made for the curved boundaries. Figure 5.1 shows this approximation for all of the various angles. All of the envelopes have a similar shape, however, they are not concentric. The variations in the envelopes is due to the non-geometric constraints on the system, such as the actuator interference constraints.

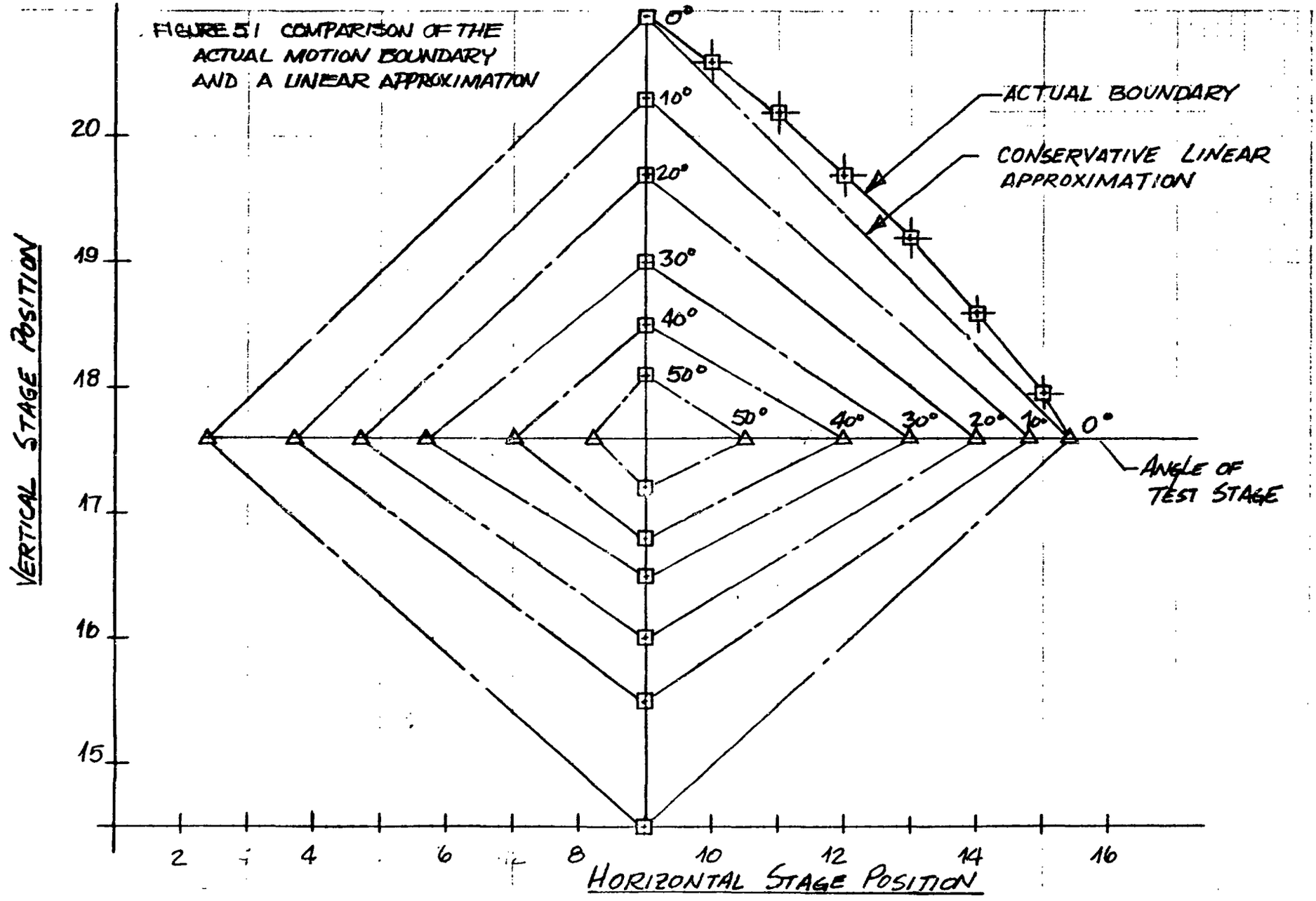
A second linearization can simplify the results further. Figure 5.2 shows the variation of the actual boundary from the center of the axis system as a function of increasing angle. The curves are non-linear which results in the non-concentric envelopes. Conservative, linear approximations were made for each axis (see Figure 5.2), which results in concentric linear envelopes, Figure 5.3.

The finalized enveloped (Figure 5.3) have the following ranges of motion

ANGLE	MAXIMUM VERTICAL RANGE (in.)	MAXIMUM HORIZONTAL RANGE (in.)
0°	5.0	13.0
10°	4.1	10.8
20°	3.2	8.8
30°	2.5	6.6
40°	1.7	4.5
50°	0.9	2.3

These ranges of motion are more than adequate to meet test requirements for all of the spinal specimens. The simplified linear approximations may be applied to the definition of a motion limit envelope used by the PMMTA control system for limit motion detection.

FIGURE 51 COMPARISON OF THE ACTUAL MOTION BOUNDARY AND A LINEAR APPROXIMATION



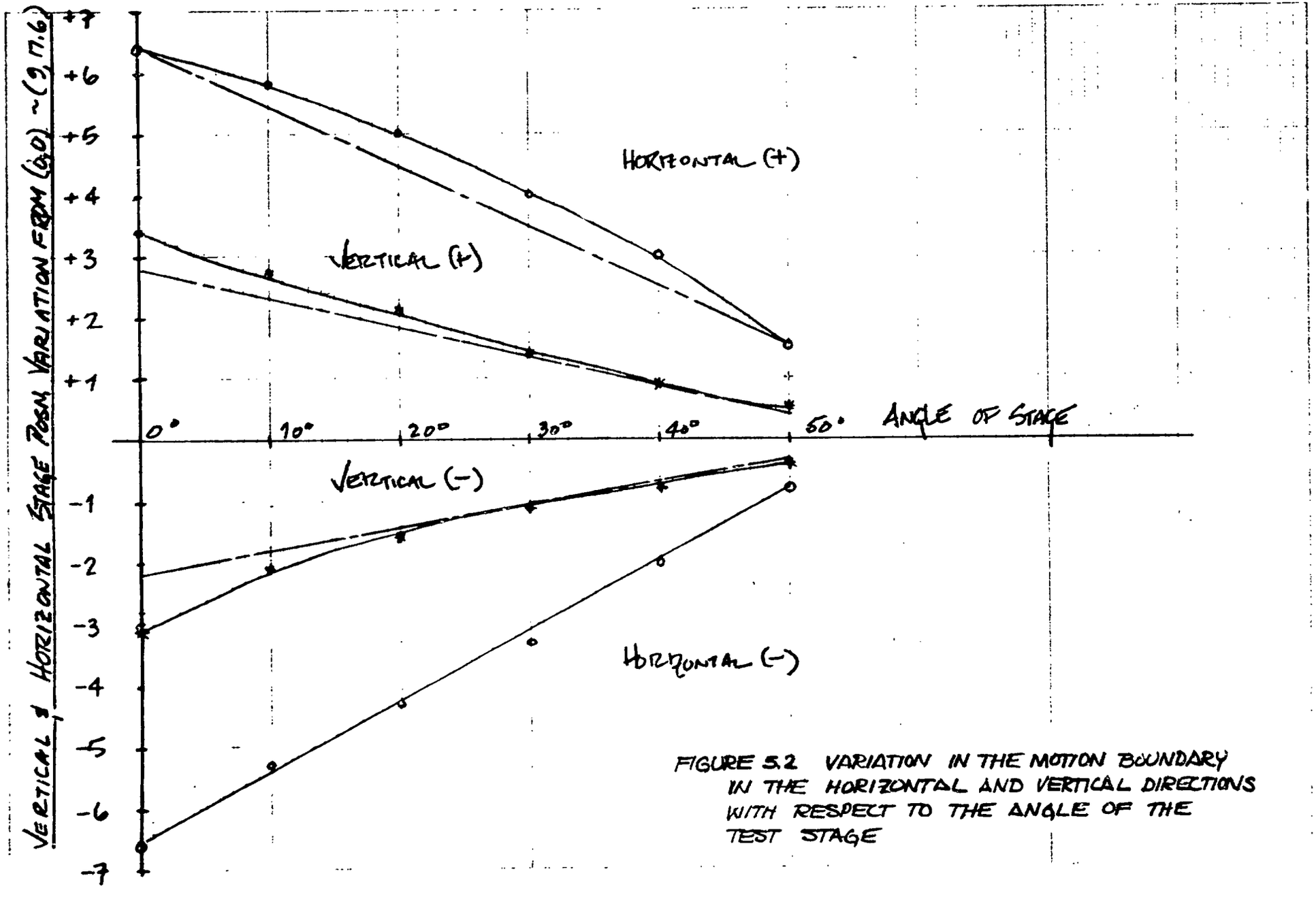


FIGURE 5.2 VARIATION IN THE MOTION BOUNDARY IN THE HORIZONTAL AND VERTICAL DIRECTIONS WITH RESPECT TO THE ANGLE OF THE TEST STAGE

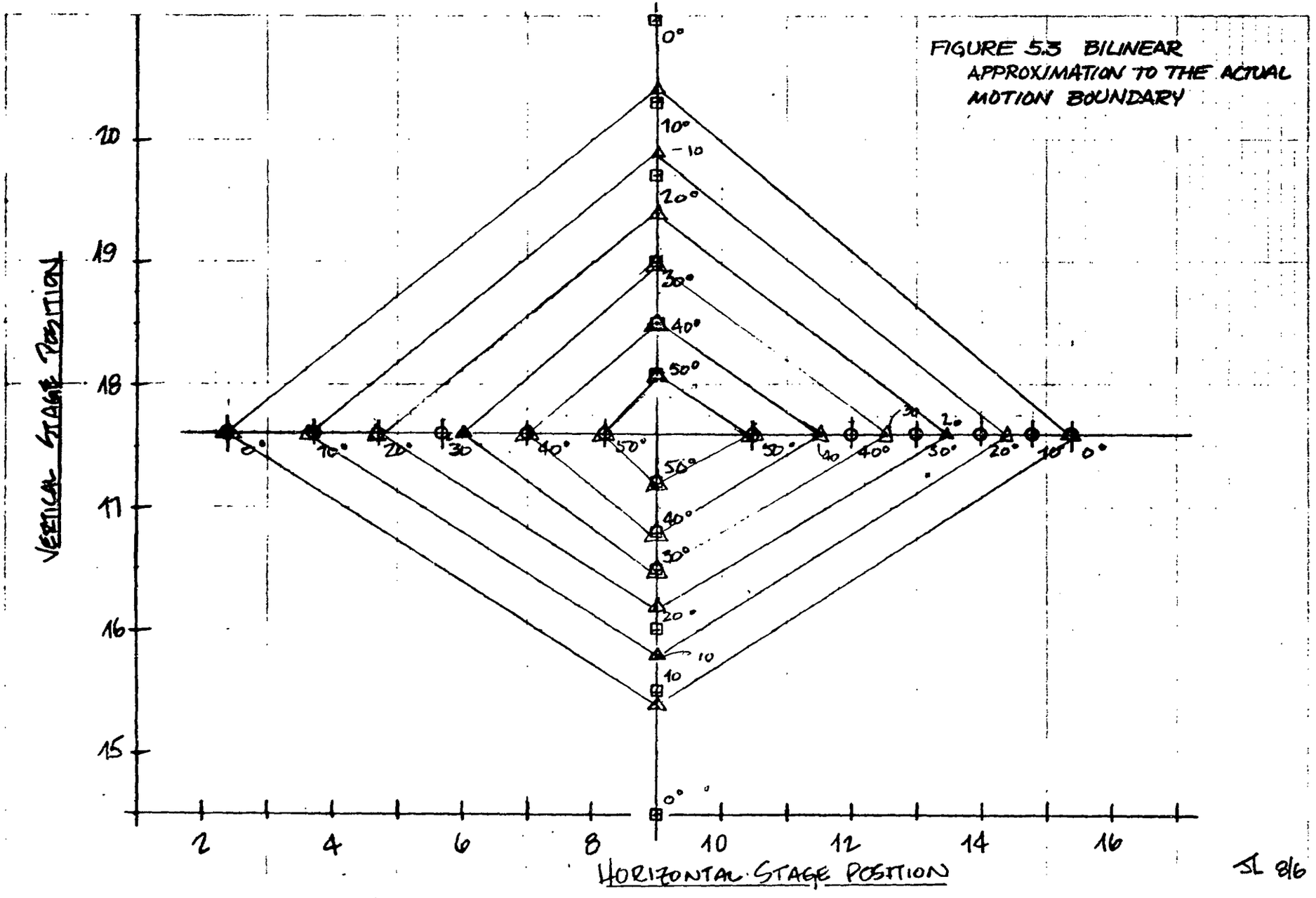


FIGURE 5.3 BILINEAR APPROXIMATION TO THE ACTUAL MOTION BOUNDARY

SL 8/6

6.0 SUMMARY

The Moog A0-85 actuator is suitable for the Planar Motion Material Testing Apparatus (PMMTA). The following conclusions may be drawn from the kinematic study of the three actuator system:

1) The PMMTA actuator configuration will utilize the lower pivot point of the actuator.

2) Considering the pivot point of the first actuator as the origin of a set of global axes, the second and third actuator pivot point locations are at (12, 0) and (18, 0) respectively. The moveable test stage is six inches long and is attached to the actuator pistons by five inch extensions.

3) The PMMTA load capacity exceeds the test requirements for vertical, horizontal and moment loading of spinal specimens by at least a factor of three. The envelope of motion of the PMMTA depends on the angle of rotation for the test stage (the size of the envelope decreasing as the absolute value of the angle increases).

4) The smallest envelope of motion for the specimen test stage is 0.9 in. vertical and 2.3 in. horizontal at 50° angle of the test stage. This exceeds the requirements for testing spinal specimens.

7.0 REFERENCES

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2. Messerer, O.: Uber Elasticitat and Festigkeit der Meuschlichen Knochen. Stutgart, J.G. Cottaschen Buchhandling, 1880.

3. Perry, O.: Fracture of the Vertebral End-Plate in the Lumbar Spine. Acta Orthop. Scand., 25 (Supple), 1957.

4. Weiss, E.B.: Stress at the Lumbosacral Junction. Ortho. Clin. N. Amer. 66:83, 1975.

5. White, A.A. and Panjabi, M.M.: Clinical Biomechanics of the Spine, J.B. Lippincott, Co., Philadelphia, PA, 1978.

APPENDIX A:

Appendix A contains a listing of the various subroutines used in the Kinematic study.

```
C PROGRAM TO STUDY THE KINEMATICS OF THE THREE ACTUATOR SYSTEM
C FILE : 3ACKIN.F04
C
      PROGRAM ACTKIN
C
      LOGICAL*1 FNOUT(14)
      LOGICAL PLT,HDC,PLN
      INTEGER OUTDEV
      DIMENSION DAY(3)
      COMMON/ACT/ NA,A(2,75),RA(2,75)
      COMMON/CONTRL/ IPC
      COMMON/LDFRM/ S,EXP,X2,X3
      COMMON/PL/ PL1,PL2,PL3
      COMMON/PLTWIN/ XMN,XMX,YMN,YMX
      COMMON/TST/ NTS,TS(2,13),RTS(2,13)
      COMMON/GEOM/TH1,TH2,TH3,TH,
     &            U1(2),U2(2),U3(2)
      COMMON/COORD/XC,YC,PH
C
C
      CALL DATE(DAY)
      NA=75
      NTS=13
      NCAS=100
C
C OPEN two scratch files, UNIT=50 and UNIT=51 for the force output
C
      OPEN(UNIT=50,TYPE='SCRATCH',INITIALSIZE=50,
     &                 RECORDSIZE=30)
      OPEN(UNIT=51,TYPE='SCRATCH',INITIALSIZE=50,
     &                 RECORDSIZE=30)
C
C Read ACTUATOR data
C
      OPEN(UNIT=20,NAME='3ACTUA.DAT',TYPE='OLD',ACCESS='SEQUENTIAL')
      READ(20,*) (I,A(1,I),A(2,I),I=1,NA)
      CLOSE(UNIT=20)
C
C Read TEST STAGE data
C
      OPEN(UNIT=20,NAME='3TSTST.DAT',TYPE='OLD',ACCESS='SEQUENTIAL')
      READ(20,*) (I,TS(1,I),TS(2,I),I=1,NTS)
      CLOSE(UNIT=20)
C
C Read INPUT data
C
      OPEN(UNIT=20,NAME='3ACKIN.I01',TYPE='OLD',ACCESS='SEQUENTIAL')
C
C SET AN OUTPUT DEVICE : Printer (P), File (FILE NAME)
C                        A Terminal is NOT allowed because plottins
C
      READ(20,314) FNOUT
314   FORMAT(14A1)
      OUTDEV=6
      IF(FNOUT(1) .EQ. 'P') GOTO 8
      OUTDEV=25
      OPEN(UNIT=25,TYPE='NEW',ACCESS='SEQUENTIAL',NAME=FNOUT,ERR=800)
      GOTO 8
800      CONTINUE
         TYPE *,' ERROR IN THE OUTPUT FILE NAME:'
         TYPE 801,FNOUT,DAY
```

```
801         FORMAT(' FILE NAME: '10A1,60X,'DATE : ' 3A4)
            STOP
C
8       CONTINUE
        IF(OUTDEV .EQ. 6) OPEN(UNIT=6,NAME='LP:',RECORDSIZE=132,
        & ACCESS='SEQUENTIAL',FORM='FORMATTED',CARRIAGECONTROL='FORTRAN')
C
        PLT=.FALSE.
        READ(20,50) RESP
50      FORMAT(A1)
        IF(RESP .EQ. 'P') PLT=.TRUE.
C
        HDC=.FALSE.
        READ(20,50) RESP
        IF(RESP .EQ. 'H') HDC=.TRUE.
C
        PLN=.FALSE.
        READ(20,50) RESP
        IF(RESP .EQ. 'P') PLN=.TRUE.
C
        READ(20,*) XMN,XMX,YMN,YMX
        READ(20,*) IPIVOT
        READ(20,*) S,EXP,X2,X3
C
        IF(PLT) CALL PLTHD
        CALL WRTHD(OUTDEV,DAY)
        CALL WRTFHT(50,DAY)
        CALL WRTFHG(51,DAY)
C
C Read the actuator lengths to be plotted
C
        DO 1 I=1,NCAS
            IF(.NOT. PLN) GOTO 5
                READ(20,*,END=900) IPC,XC,YC,PH
                CALL PSTLEN (IPIVOT)
                IF(P1 .GT. 6.) GOTO 1
                IF(P2 .GT. 6.) GOTO 1
                IF(P3 .GT. 6.) GOTO 1
                GOTO 6
5               READ(20,*,END=900) IPC,PL1,PL2,PL3
6               CONTINUE
            IF(IPC .NE. 8) GOTO 2
                IF(PLT .AND. HDC) CALL HDCPY
                IF( (.NOT. PLT) .OR. (PLT .AND. HDC) ) GOTO 3
                   CALL ALPH
                   IF(PLT .AND. .NOT. HDC) ACCEPT 50,RESP
                   CALL INITT
3               CONTINUE
C       Check for the END of UNIT=20
                READ(20,*,END=900)
                BACKSPACE 20
                IF(PLT) CALL PLTHD
                CALL DASH(OUTDEV,50,51)
                I=I-1
                GOTO 1
C
C Produce output for plotting and writing
C
2           CONTINUE
            CALL KINCAL(IPIVOT)
            IF(PLT .AND. IPC.EQ.1) CALL PLTOUT(IPIVOT)
```

```
            CALL WRTOUT(OUTDEV,I)
            CALL FORCAL
            CALL WRTFOR(50,51,I)
    1     CONTINUE
    C
    300   CONTINUE
          CALL FORMFD(OUTDEV)
          CALL DUMPFL(OUTDEV,50)
    C
          CALL FORMFD(OUTDEV)
          CALL DUMPFL(OUTDEV,51)
    C
          IF(OUTDEV .EQ. 6) CLOSE(UNIT=6)
          CLOSE(UNIT=20)
          IF(OUTDEV .EQ. 25) CLOSE(UNIT=25)
    C
          END
```

```
      FUNCTION ANGL(COSA)
      SINA=SQRT(1.-COSA*COSA)
      ANGL=ATAN(SINA/COSA)
      PI=4.*ATAN(1.)
      IF(ANGL .LT. 0.) ANGL=PI+ANGL
      END
C
C
      SUBROUTINE FORMFD(OUTDEV)
      INTEGER OUTDEV
      WRITE(OUTDEV,100) 12
100   FORMAT(' ',A1)
      END
```

```
      SUBROUTINE DASH(NOUT0,NOUT1,NOUT2)
      WRITE(NOUT0,100)
      WRITE(NOUT1,101)
      WRITE(NOUT2,102)
100   FORMAT(1X,88('-'))
101   FORMAT(1X,82('-'))
102   FORMAT(1X,82('-'))
      END
```

```
      SUBROUTINE DUMPFL(OUTDEV,NU)
      INTEGER OUTDEV
      DIMENSION A(30)
C
      REWIND NU
      DO 1 I=1,500
      READ(NU,100,END=900) A
      WRITE(OUTDEV,200) A
1     CONTINUE
900   CONTINUE
      CLOSE(UNIT=NU)
C
100   FORMAT(30A4)
200   FORMAT(1X,30A4)
      END
```

```
      SUBROUTINE KINCAL(IPIVOT)
C
      COMMON/LDFRM/ S,EXP,X2,X3
      COMMON/PL/ PL1,PL2,PL3
      COMMON/TST/ NTS,TS(2,13),RTS(2,13)
      COMMON/GEOM/TH1,TH2,TH3,TH,
     &            U1(2),U2(2),U3(2)
C
C
      SINA(COSA)=SQRT(1. - COSA*COSA)
      PI=4.*ATAN(1.)
C
C
C Kinematic relations for the 3 DOF test appartatus
C
      EXB=0.
      IF(IPIVOT .EQ. 53) EXB=9.14
      EXT=EXP+EXB
      D1=PL1+EXT
      D2=PL2+EXT
      D3=PL3+EXT
      CTH1=(D1*D1 + X2*X2 - D2*D2)/(2.*D1*X2)
      TH1=ANGL(CTH1)
      U1(1)=D1*CTH1
      U1(2)=D1*SINA(CTH1)
C
      CTH2=(D1*CTH1-X2)/D2
      TH2=ANGL(CTH2)
C
      DX=X3-X2
      D=SQRT(D2*D2 + DX*DX - 2.*D2*DX*CTH2)
      CTH3P=(DX-D2*CTH2)/D
      STH3P=SINA(CTH3P)
      CTH3PP=(D*D + D3*D3 - S*S)/(2.*D*D3)
      STH3PP=SINA(CTH3PP)
      TH3=PI - (ANGL(CTH3P) + ANGL(CTH3PP))
      U2(1)=X3-D3*(CTH3P*CTH3PP - STH3P*STH3PP)
      U2(2)=D3*(STH3P*CTH3PP + CTH3P*STH3PP)
C
      U3(1)=0.5*(U1(1) + U2(1))
      U3(2)=0.5*(U1(2) + U2(2))
      TH=ATAN( (U2(2)-U1(2)) / (U2(1)-U1(1)) )
C
      END
```

```
      SUBROUTINE PLTHD
C
      COMMON/LDFRM/ S,EXP,X2,X3
      COMMON/PLTWIN/ XMN,XMX,YMN,YMX
C
C
C Set up plot area and type headings
C
      CALL ERASE
      CALL CURSOR(0.,750.)
      TYPE 100,S,EXP,X2,X3
100   FORMAT(40X,'ACTUATOR KINEMATIC STUDY'/
     &     45X,'TEST STAGE LENGTH ='F5.2/
     &     45X,'EXTENSION DISTANCE='F5.2/
     &     45X,'POSITION OF ACT #2='F5.2/
     &     45X,'POSITION OF ACT #3='F5.2)
      CALL CURSOR(0.,750.)
      TYPE 200
200   FORMAT('  MOOG A0-85'/'  ACTUATOR')
      CALL CURSOR(0.,15.)
      TYPE 101
101   FORMAT(65X,'WTE')
C
      CALL INITB
C
C Draw the Actuator Model
C
      CALL WIND(1.,-20.,5.,-2.,8.,0.,5.25)
      CALL WINDBD
      CALL PLTACT(51,0.,0.,0.,0.,1.)
C
C Setup the drawing window
C
      CALL WIND(6.25,XMN,XMX,YMN,YMX,0.,0.)
      CALL WINDBD
      CALL AXIS(1.)
c
      END
```

```
      SUBROUTINE PLTOUT(IPIVOT)
C
      COMMON/LDFRM/ S,EXP,X2,X3
      COMMON/PL/ PL1,PL2,PL3
      COMMON/TST/ NTS,TS(2,13),RTS(2,13)
      COMMON/GEOM/TH1,TH2,TH3,TH,
     &            U1(2),U2(2),U3(2)

C
C Plot the actuators and the load platten
C FORM : CALL PLTACT(IPIVOT,XA,YA,TH,PL,AM)
C
      CALL PLTACT(IPIVOT,0.,0.,TH1,PL1,1.)
      CALL PLTACT(IPIVOT,X2,0.,TH2,PL2,1.)
      CALL PLTACT(IPIVOT,X3,0.,TH3,PL3,-1.)
C
      XA=U1(1)
      YA=U1(2)
      CALL SCLBOD(NTS,TS,RTS,1,1,2,S)
      CALL ROTATE(NTS,RTS,RTS,1,XA,YA,TH)
      CALL PLTTS
      END
```

```
      SUBROUTINE WRTHD(OUTDEV,DAY)
      INTEGER OUTDEV
      DIMENSION DAY(3)
C
      COMMON/LDFRM/ S,EXP,X2,X3
      COMMON/TST/ NTS,TS(2,13),RTS(2,13)
C
C Write header to OUTDEV
C
      WRITE(OUTDEV,300) DAY
      WRITE(OUTDEV,301) 0.,0.,S,X2,0.,TS(2,13),X3,0.,EXP
      WRITE(OUTDEV,302)
C
300   FORMAT(' KINEMATICS OF THE THREE ACTUATOR SYSTEM'20X'DATE : '3A4/
     &  4X' ACTUATOR: MOOG - A085 - 6 IN STROKE')
301   FORMAT(/5X' ACTUATOR PIVOT POSITION: ',20X,'TEST STAGE'/
     &       10X' ACTUATOR #1 ('F5.2','F5.2')'20X'LENGTH:'F8.3/
     &       10X' ACTUATOR #2 ('F5.2','F5.2')'20X'HEIGHT:'F8.3/
     &       10X' ACTUATOR #3 ('F5.2','F5.2')'15X
     &          'ACTUATOR EXTENSION:'F8.3)
302   FORMAT(//'          '|   PL1   |   PL2   |   PL3   |',
     &'       REF PNT       |  THETA  |       STG POS       |'/
     &'         CASE  |   (IN)  |   (IN)  |   (IN)  |',
     &'    X    |     Y   |  (RAD)  |    X    |    Y    |'/
     &'         ------------------------------------------',
     &'-----------------------------------------------')
      END
```

```
      SUBROUTINE WRTOUT(OUTDEV,NC)
C
      LOGICAL*1 IPA(2),IFA(2)
      INTEGER OUTDEV
C
      COMMON/CONTRL/ IPC
      COMMON/LDFRM/ S,EXP,X2,X3
      COMMON/PL/ PL1,PL2,PL3
      COMMON/TST/ NTS,TS(2,13),RTS(2,13)
      COMMON/GEOM/TH1,TH2,TH3,TH,
     &            U1(2),U2(2),U3(2)
      DATA IPA/' ','P'/
C
C Write the calculated output data
C
         XA=U1(1)
         YA=U1(2)
         CALL SCLBOD(NTS,TS,RTS,1,1,2,S)
         CALL ROTATE(NTS,RTS,RTS,1,XA,YA,TH)
         WRITE(OUTDEV,303) IPA(IPC+1),NC,
     &        PL1,PL2,PL3,
     &        U3(1),U3(2),TH,RTS(1,13),RTS(2,13)
C
303      FORMAT(2X,A1,I4' |',8(F8.4,1X'|'))
      END
```

```
      SUBROUTINE FORCAL
      COMMON/LDFRM/S,EXP,EX2,EX3
      COMMON/FORCES/X1(3),Y1(3),X2(3),Y2(3),XR1(3),YR1(3),RM0(3),
     &              X1L(3),Y1L(3),X2L(3),Y2L(3),XRL(3),YRL(3)
      COMMON/GEOM/TH1,TH2,TH3,TH,U1(2),U2(2),U3(2)
      DIMENSION F1(3),F2(3),F3(3)
C
C
      PI=4.*ATAN(1.)
      SIN0=SIN(TH)
      COS0=COS(TH)
      SIN1=SIN(TH1)
      COS1=COS(TH1)
      SIN2A=SIN(PI-TH2)
      COS2A=COS(PI-TH2)
      SIN3A=SIN(PI-TH3)
      COS3A=COS(PI-TH3)
      F1(1)=3300.
      F2(1)=3300.
      F3(1)=3300.
      F1(2)=3300.
      F2(2)=-3300.
      F3(2)=-3300.
      F1(3)=3300.
      F2(3)=3300.
      F3(3)=-3300.
C
C
C     Resolution of input forces and reaction forces to global coordinates
C     on the test stage.
C
      DO 5 J=1,3
      Y1(J)=F1(J)*SIN1+F2(J)*SIN2A
      Y2(J)=F3(J)*SIN3A
      X1(J)=-F2(J)*COS2A+F1(J)*COS1
      X2(J)=-F3(J)*COS3A
      XR1(J)=-(X1(J)+X2(J))
      YR1(J)=-(Y1(J)+Y2(J))
C     Resolution of input forces and reaction forces to local coordinates
C     on the test stage.
C
      Y1L(J)=Y1(J)*COS0-X1(J)*SIN0
      Y2L(J)=Y2(J)*COS0-X2(J)*SIN0
      X1L(J)=Y1(J)*SIN0+X1(J)*COS0
      X2L(J)=Y2(J)*SIN0+X2(J)*COS0
      YRL(J)=YR1(J)*COS0-XR1(J)*SIN0
      XRL(J)=YR1(J)*SIN0+XR1(J)*COS0
      RM0(J)=(Y1L(J)-Y2L(J))*S/2-1.75*(X1L(J)+X2L(J))
C
5     CONTINUE
      END
```

```
      SUBROUTINE WRTFHT(OUTDEV,DAY)
      INTEGER OUTDEV
      DIMENSION DAY(3)
C
      COMMON/LDFRM/ S,EXP,X2,X3
      COMMON/TST/ NTS,TS(2,13),RTS(2,13)
C
C Write header to OUTDEV, a scratch file
C
      WRITE(OUTDEV,300) DAY
      WRITE(OUTDEV,301) 0.,0.,S,X2,0.,TS(2,13),X3,0.,EXP
      WRITE(OUTDEV,302)
C
300   FORMAT(' FORCES ON TEST STAGE (LOCAL COORDINATES)'19X'DATE : '3A4/
     &    4X' ACTUATOR: MOOG - A085 - 6 IN STROKE')
301   FORMAT(/5X' ACTUATOR PIVOT POSITION: ',20X,'TEST STAGE'/
     &      10X' ACTUATOR #1 ('F5.2','F5.2')'20X'LENGTH:'F8.3/
     &      10X' ACTUATOR #2 ('F5.2','F5.2')'20X'HEIGHT:'F8.3/
     &      10X' ACTUATOR #3 ('F5.2','F5.2')'15X
     &         'ACTUATOR EXTENSION:'F8.3)
302   FORMAT(//'           |   FX1   |   FY1   |   FX2   |',
     &'   FY2   |   FRX   |   FRY   |  MOMENT  |'/
     &        ' CASE/DIR |   (LBS) |   (LBS) |   (LBS) |',
     &'   (LBS) |   (LBS) |   (LBS) | (IN-LBS) |'/
     &,1X,82('-'))
      END
```

```
      SUBROUTINE WRTFHG(OUTDEV,DAY)
      INTEGER OUTDEV
      DIMENSION DAY(3)
C
      COMMON/LDFRM/ S,EXP,X2,X3
      COMMON/TST/ NTS,TS(2,13),RTS(2,13)
C
C Write header to OUTDEV, a scratch file
C
      WRITE(OUTDEV,300) DAY
      WRITE(OUTDEV,301) 0.,0.,S,X2,0.,TS(2,13),X3,0.,EXP
      WRITE(OUTDEV,302)
C
300   FORMAT(' FORCES ON TEST STAGE (GLOBAL COORDINATES)'
     &    18X'DATE : '3A4/
     &    4X' ACTUATOR: MOOG - A085 - 6 IN STROKE')
301   FORMAT(/5X' ACTUATOR PIVOT POSITION: ',20X,'TEST STAGE'/
     &      10X' ACTUATOR #1 ('F5.2','F5.2')'20X'LENGTH:'F8.3/
     &      10X' ACTUATOR #2 ('F5.2','F5.2')'20X'HEIGHT:'F8.3/
     &      10X' ACTUATOR #3 ('F5.2','F5.2')'15X
     &         'ACTUATOR EXTENSION:'F8.3)
302   FORMAT(//'           |   FX1   |   FY1   |   FX2   |',
     &'   FY2   |   FRX   |   FRY   |  MOMENT  |'/
     &        ' CASE/DIR |   (LBS) |   (LBS) |   (LBS) |',
     &'   (LBS) |   (LBS) |   (LBS) | (IN-LBS) |'/
     &,1X,82('-'))
      END
```

```
      SUBROUTINE WRTFOR(NOUTO,NOUT1,NC)
      LOGICAL*1 A(3)
      COMMON/FORCES/X1(3),Y1(3),X2(3),Y2(3),XR1(3),YR1(3),RMO(3),
     &              X1L(3),Y1L(3),X2L(3),Y2L(3),XRL(3),YRL(3)
      DATA A/'V','H','M'/
C
      WRITE(NOUTO,200) NC,(A(I),X1L(I),Y1L(I),X2L(I),Y2L(I),
     &                  XRL(I),YRL(I),RMO(I),I=1,3)
      WRITE(NOUT1,200) NC,(A(I),X1(I),Y1(I),X2(I),Y2(I),
     &                  XR1(I),YR1(I),RMO(I),I=1,3)
C
200   FORMAT(1X,I4,2X,A1'  |',6(F8.1,1X'|'),F9.1,1X'|'/
     &       7X,      A1'  |',6(F8.1,1X'|'),F9.1,1X'|'/
     &       7X,      A1'  |',6(F8.1,1X'|'),F9.1,1X'|')
      END
```

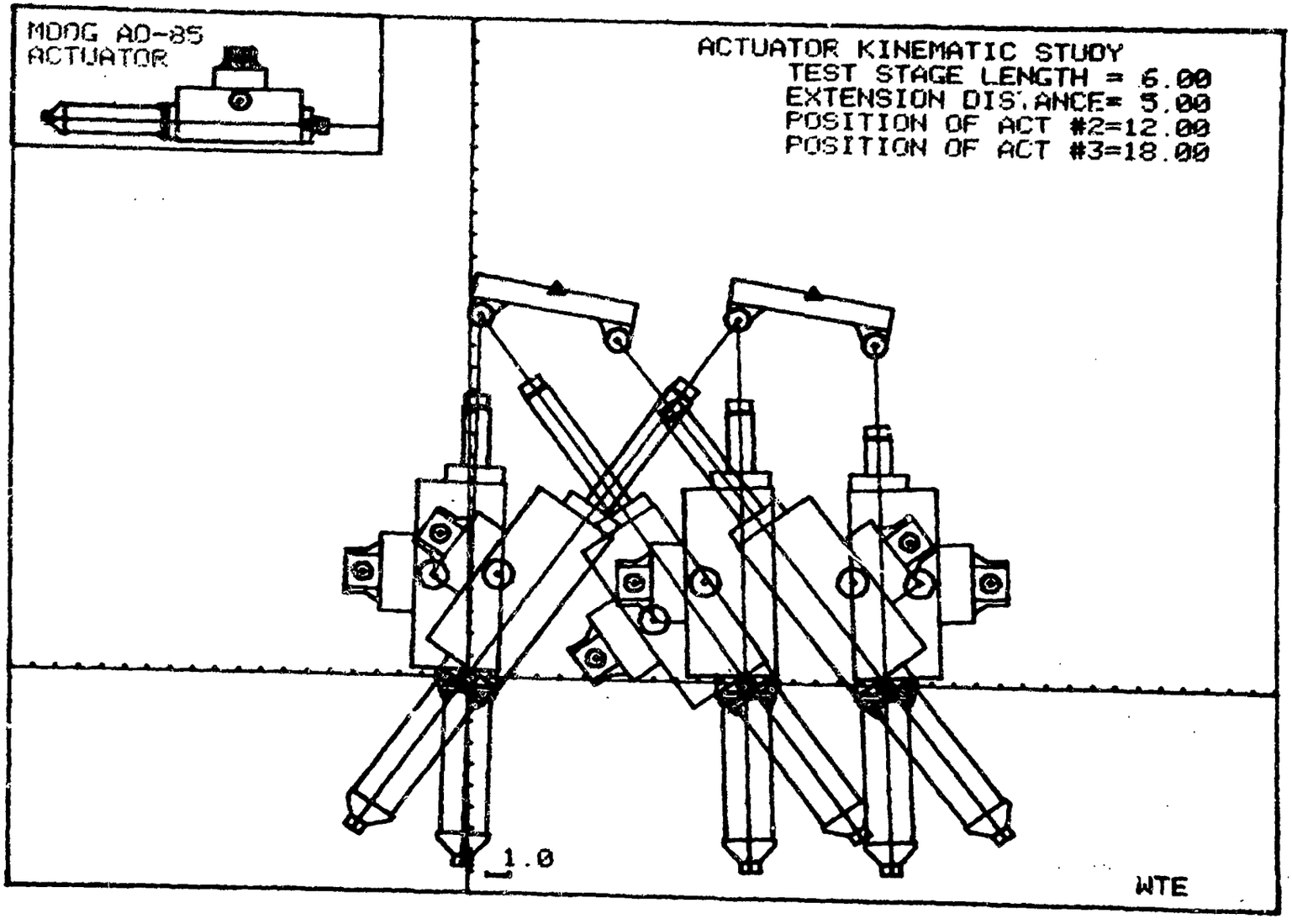
```
      SUBROUTINE PSTLEN (IPIVOT)
C
      COMMON/LDFRM/S,EXP,X2,X3
     .COMMON/PL/PL1,PL2,PL3
      COMMON/COORD/XC,YC,PH0
      COMMON/CONTRL/IPC
C
C
      PI=4.*ATAN(1.)
      PH=PH0*PI/180.
C
C Calculations of piston lengths given  Stage position and Angle (PH).
C
C
      R2=XC+S/2.*COS(PH)+1.75*SIN(PH)
      R1=XC-S/2.*COS(PH)+1.75*SIN(PH)
      S1=YC-S/2.*SIN(PH)-1.75*COS(PH)
      S2=YC+S/2.*SIN(PH)-1.75*COS(PH)
C
      PL1=SQRT((R1**2)+(S1**2))
      PL2=SQRT(((X2-R1)**2)+(S1**2))
      PL3=SQRT(((X3-R2)**2)+(S2**2))
C
      EXB=0.
      IF(IPIVOT .EQ. 53) EXB=9.14
      EXT=EXP+EXB
      PL1=PL1-EXT
      PL2=PL2-EXT
      PL3=PL3-EXT
C
      END
```

APPENDIX B:

Each figure in Appendix 3 represents maximum/minimum positions for the test stage at a specific angle. Included with each figure in the kinematic dimensions along with the maximum local and global forces and moments on the test stage.

The contents of the Figures are as follows:

Figure : Horizontal max/min position @ -10°
Horizontal max/min position @ $+10^{\circ}$
Horizontal max/min position @ -20°
Horizontal max/min position @ $+20^{\circ}$
Horizontal max/min position @ -40°
Horizontal max/min position @ $+40^{\circ}$
Horizontal max/min position @ -50°
Horizontal max/min position @ $+50^{\circ}$
Vertical max/min position @ -10°
Vertical max/min position @ $+10^{\circ}$
Vertical max/min position @ -20°
Vertical max/min position @ $+20^{\circ}$
Vertical max/min position @ -40°
Vertical max/min position @ $+40^{\circ}$
Vertical max/min position @ -50°
Vertical max/min position @ $+50^{\circ}$


MOOG AO-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: HOOG - ADBS - 6 IN STROKE

DATE : 03-AUG-81

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 8.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	2.2635	5.9217	5.1345	3.3961	15.8766	-0.1745	3.7000	17.6000
P 2	5.9122	2.2639	1.2255	14.4961	15.8766	-0.1745	14.8000	17.6000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: MOOG - AOOS - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

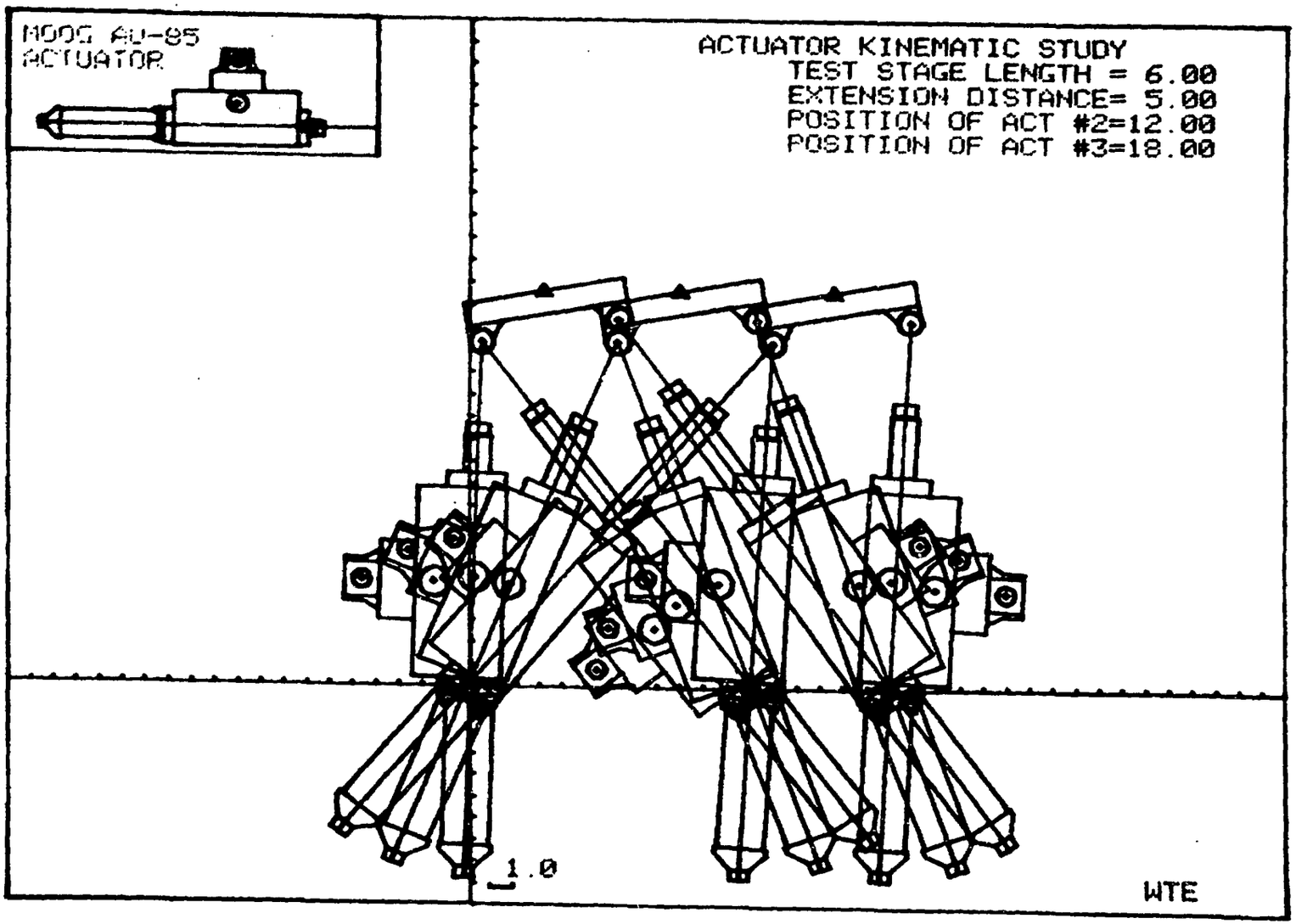
CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-2826.1	5590.3	-2420.7	2242.8	5246.8	-7833.0	15224.4
H	1855.4	838.0	2420.7	-2242.8	-4276.2	1304.8	2058.9
M	-2826.1	5590.3	2420.7	-2242.8	405.3	-3347.5	24208.4
2 V	738.4	8220.0	-888.9	3227.3	-48.5	-9447.3	8891.5
H	2065.6	-245.2	888.9	-3227.3	-2754.5	3472.5	4126.0
M	738.4	8220.0	888.9	-3227.3	-1427.2	-2892.7	25844.1

FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 03-AUG-81
ACTUATOR: MOOG - A985 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-1812.4	5996.1	-1994.5	2628.1	3906.8	-8625.1	19224.4
H	1950.1	601.5	1994.5	-2628.1	-3994.6	2027.5	2058.9
M	-1812.4	5996.1	1994.5	-2628.1	-182.1	-3367.0	24208.4
2 V	1807.2	5997.3	-118.0	3297.9	-1688.2	-9295.2	8481.5
H	1991.6	-600.2	118.0	-3297.9	-2108.6	3696.0	4126.0
M	1807.2	5997.3	118.0	-3297.9	-1825.2	-2699.4	25944.1


MOOG AU-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

ACTUATOR: MOOG - AD85 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	1.2238	5.0448	5.9410	3.4535	15.8766	0.1745	3.1500	17.6000
P 2	2.4766	2.2223	3.2337	9.3039	15.8766	0.1745	9.0000	17.6000
P 3	5.9468	1.2450	2.2800	15.9039	15.8765	0.1745	15.6000	17.6000

ACTUATOR: M50G - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-811.1	6174.2	-1408.1	2984.5	2219.2	-9158.8	13452.7
H	2167.9	284.8	1408.1	-2984.5	-3575.9	2699.7	3550.1
M	-811.1	6174.2	1408.1	-2984.5	-596.9	-3189.7	26431.7
2 V	1186.9	6032.1	-533.2	3256.6	-653.7	-9288.7	7182.4
H	2355.9	-463.5	533.2	-3256.6	-2889.1	3720.2	3323.4
M	1186.9	6032.1	533.2	-3256.6	-1720.0	-2775.5	24856.2
3 V	3305.7	5323.3	742.1	3215.5	-4047.8	-8538.7	-760.2
H	1760.7	-1093.3	-742.1	-3215.5	-1018.5	4308.8	4584.0
M	3305.7	5323.3	-742.1	-3215.5	-2563.5	-2107.8	21130.1

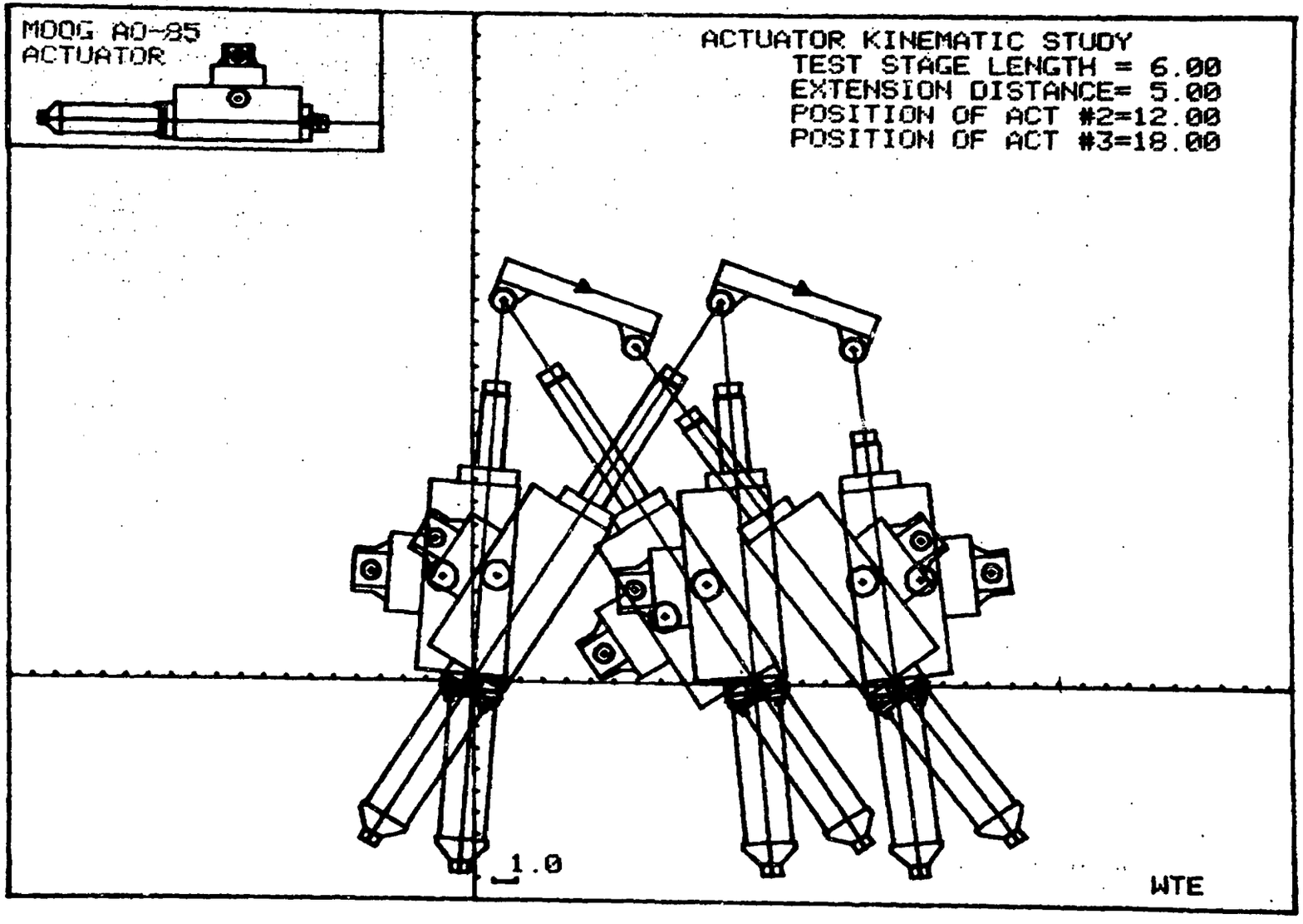
FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 30-JUL-87

ACTUATOR: MOOG - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 8.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-1870.9	5939.6	-1904.9	2694.7	3775.5	-8634.3	13452.7
H	2085.5	656.9	1904.9	-2694.7	-3990.4	2037.8	3550.1
M	-1870.9	5939.6	1904.9	-2694.7	-34.0	-3244.9	26431.7
2 V	121.4	6146.6	-1050.6	3114.6	965.2	-9261.1	7162.4
H	2400.8	-47.4	1050.6	-3114.6	-3491.2	3162.0	3323.4
M	121.4	6146.6	1050.6	-3114.6	-1211.8	-3032.0	24856.2
3 V	2331.1	5816.4	172.5	3295.5	-2503.6	-9111.9	-750.2
H	1923.8	-771.0	-172.5	-3295.5	-1751.3	4066.5	4584.0
M	2331.1	5816.4	-172.5	-3295.5	-2158.6	-2520.9	21130.1


MOOG A0-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: MOOG - A085 - 6 IN STROKE

DATE : 03-AUG-81

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAND
LENGTH: 8.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	2.8899	5.9409	4.4515	4.1015	15.9555	-0.3491	4.7000	17.8000
P 2	5.8890	2.8007	0.8851	13.4015	15.9555	-0.3491	14.0000	17.8000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 03-AUG-01

ACTUATOR: M008 - A005 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

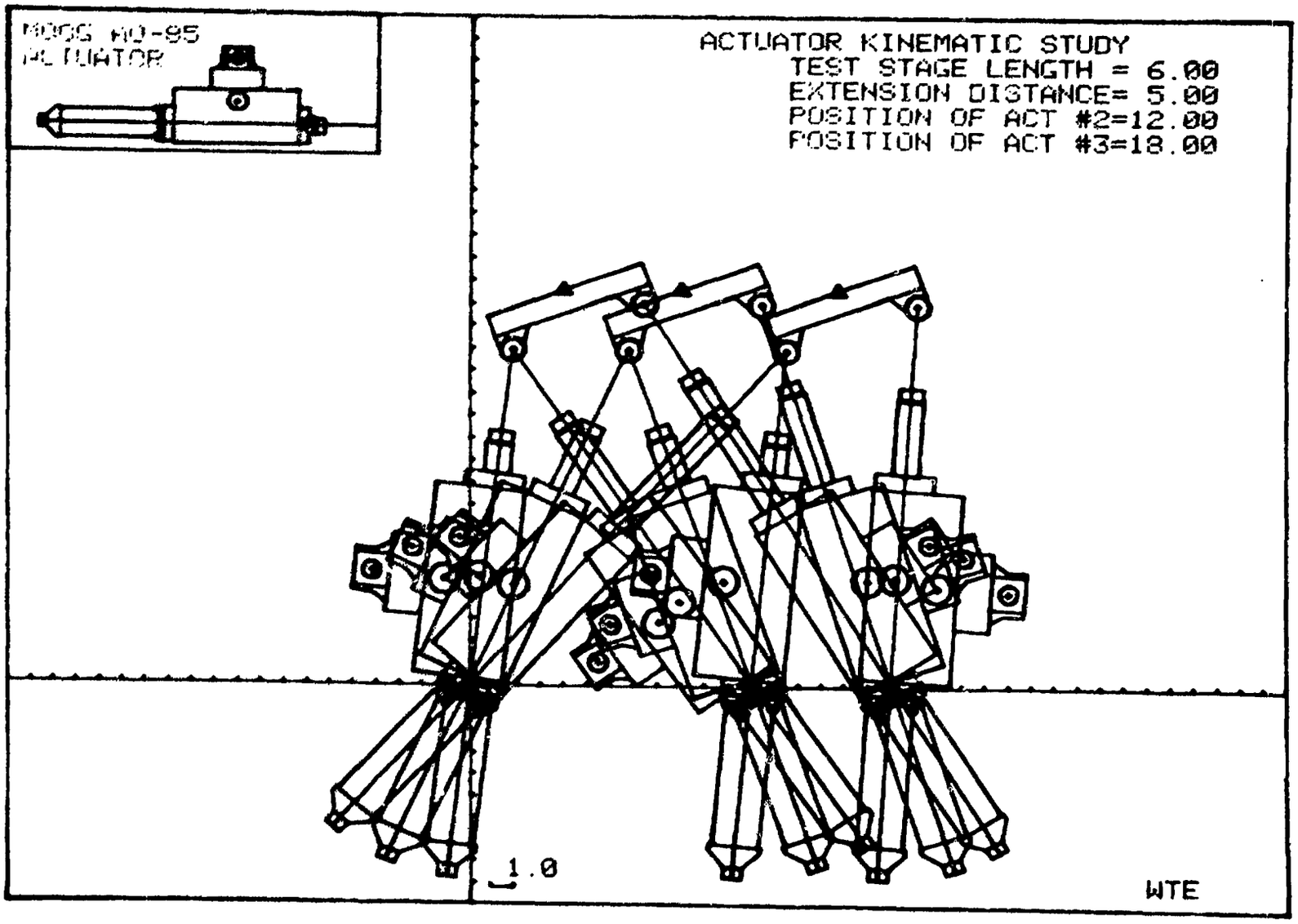
CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-3501.5	5197.2	-2754.4	1817.6	6225.9	-7014.7	21086.5
H	1717.6	1157.2	2754.4	-1817.6	-4471.9	860.4	1088.3
M	-3501.5	5197.2	2754.4	-1817.6	747.1	-3379.8	22351.8
2 V	-700.6	6225.1	-1487.7	2945.6	2188.3	-9170.7	13867.9
H	2064.9	232.4	1487.7	-2945.6	-3552.6	2713.2	3316.9
M	-700.6	6225.1	1487.7	-2945.6	-787.2	-3278.5	26134.5

FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 03-AUG-81
ACTUATOR: MOOG - ACOS - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-1512.8	8081.3	-1966.6	2850.0	3479.4	-8731.3	21086.5
H	2009.8	500.0	1966.6	-2850.0	-3876.4	2150.0	1088.3
M	-1512.8	8081.3	1966.6	-2850.0	-453.8	-3431.3	22351.6
2 V	1470.8	6089.3	-390.6	3276.8	-1080.2	-5366.1	13867.9
H	2019.8	-487.9	390.6	-3276.8	-2410.4	3764.7	3316.9
M	1470.8	6089.3	390.6	-3276.8	-1881.3	-2812.5	28134.5


MOOG MO-95
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: M088 - A085 - 6 IN STROKE

DATE : 30-JUL-81

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	0.8851	3.9528	5.8690	4.5985	15.5555	0.3491	4.0000	17.6000
P 2	2.2567	1.6758	3.7356	9.5985	15.5555	0.3491	9.0000	17.6000
P 3	5.5743	0.8626	2.8763	16.2985	15.5555	0.3491	15.7000	17.6000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 30-JUL-81

ACTUATOR: MOOG - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	667.3	6142.0	-682.2	3228.7	14.8	-9370.7	8765.9
H	2308.1	-250.8	682.2	-3228.7	-2990.3	3479.5	3700.8
M	667.3	6142.0	682.2	-3228.7	-1349.5	-2913.3	25759.6
2 V	2351.7	5656.6	103.8	3298.4	-2455.5	-8954.9	2777.6
H	2268.0	-942.5	-103.8	-3298.4	-2164.2	4241.3	3275.1
M	2351.7	5656.6	-103.8	-3298.4	-2247.9	-2358.2	22931.1
3 V	4344.8	4519.9	1325.9	3020.2	-5674.7	-7540.0	-5431.6
H	1486.9	-1429.3	-1325.9	-3020.2	-157.0	4449.5	4457.5
M	4344.8	4519.9	-1325.9	-3020.2	-3014.9	-1499.7	17344.0

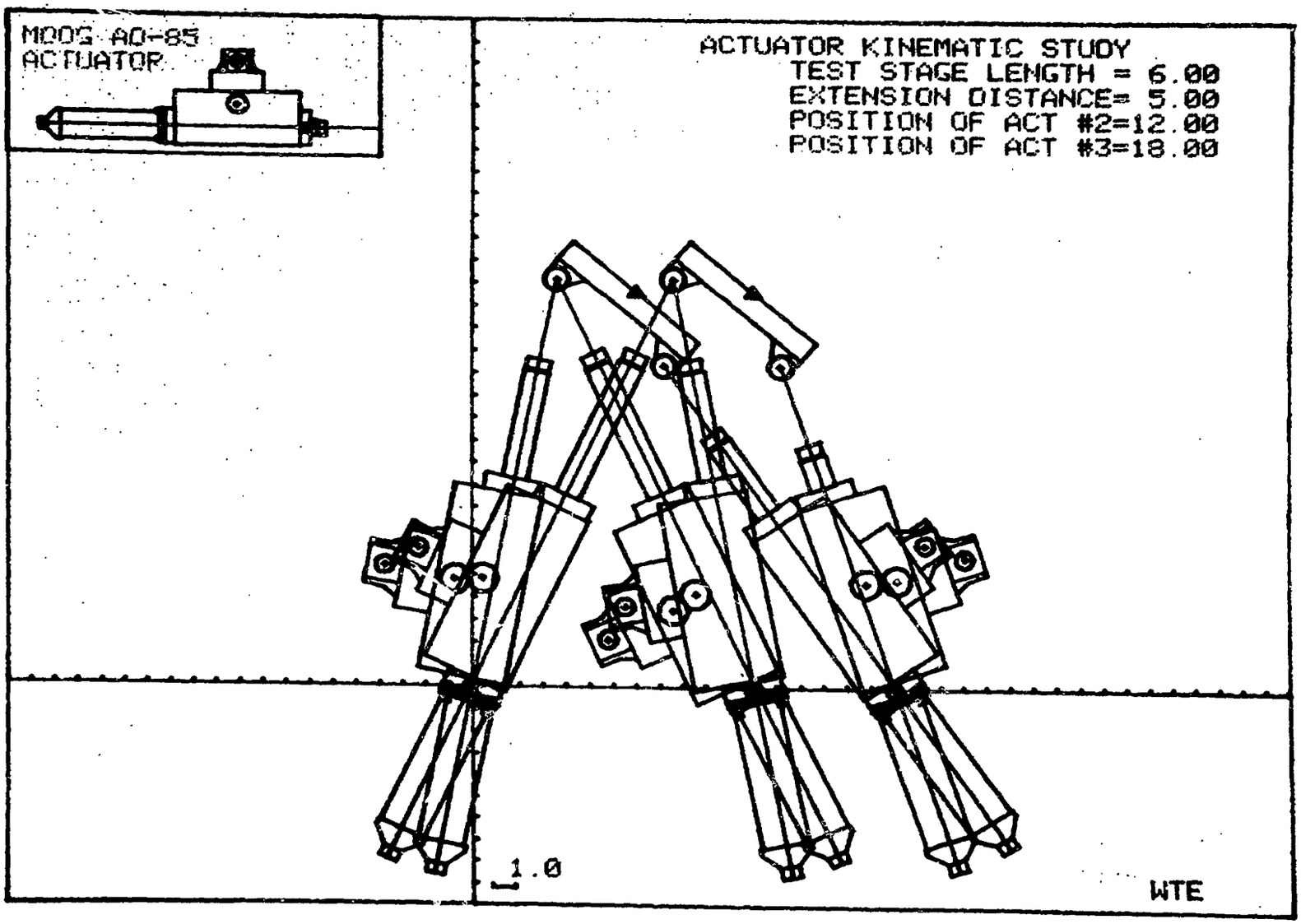
FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 30-JUL-81

ACTUATOR: MOOG - A085 - 5 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 5.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-1473.6	5889.8	-1745.3	2800.7	3218.9	-8800.5	8765.8
H	2254.7	553.8	1745.3	-2800.7	-4000.0	2246.9	3700.8
M	-1473.6	5895.9	1745.3	-2800.7	-271.7	-3155.1	25750.2
2 V	275.2	6119.6	-1030.6	3135.0	755.4	-5254.7	2777.3
H	2455.7	-110.3	1030.6	-3135.0	3484.3	3245.3	3279.1
M	275.2	6119.6	1030.6	-3135.0	-1305.7	-2984.8	22531.1
3 V	2536.9	5733.3	216.7	3292.5	-2753.6	-5028.2	-5431.6
H	1686.0	-834.6	-216.7	-3292.9	-1669.3	4127.4	4497.9
M	2533.9	5733.3	-216.7	-3292.5	-2329.2	-2440.4	17344.0


MOOG AO-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: MOOG - A085 - 6 IN STROKE

DATE : 03-AUG-81

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	4.3962	5.9035	3.2365	5.8751	16.2594	-0.6981	7.0000	17.8000
P 2	5.9887	4.3871	0.9821	10.8751	16.2594	-0.6981	12.0000	17.8000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: MOOG - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

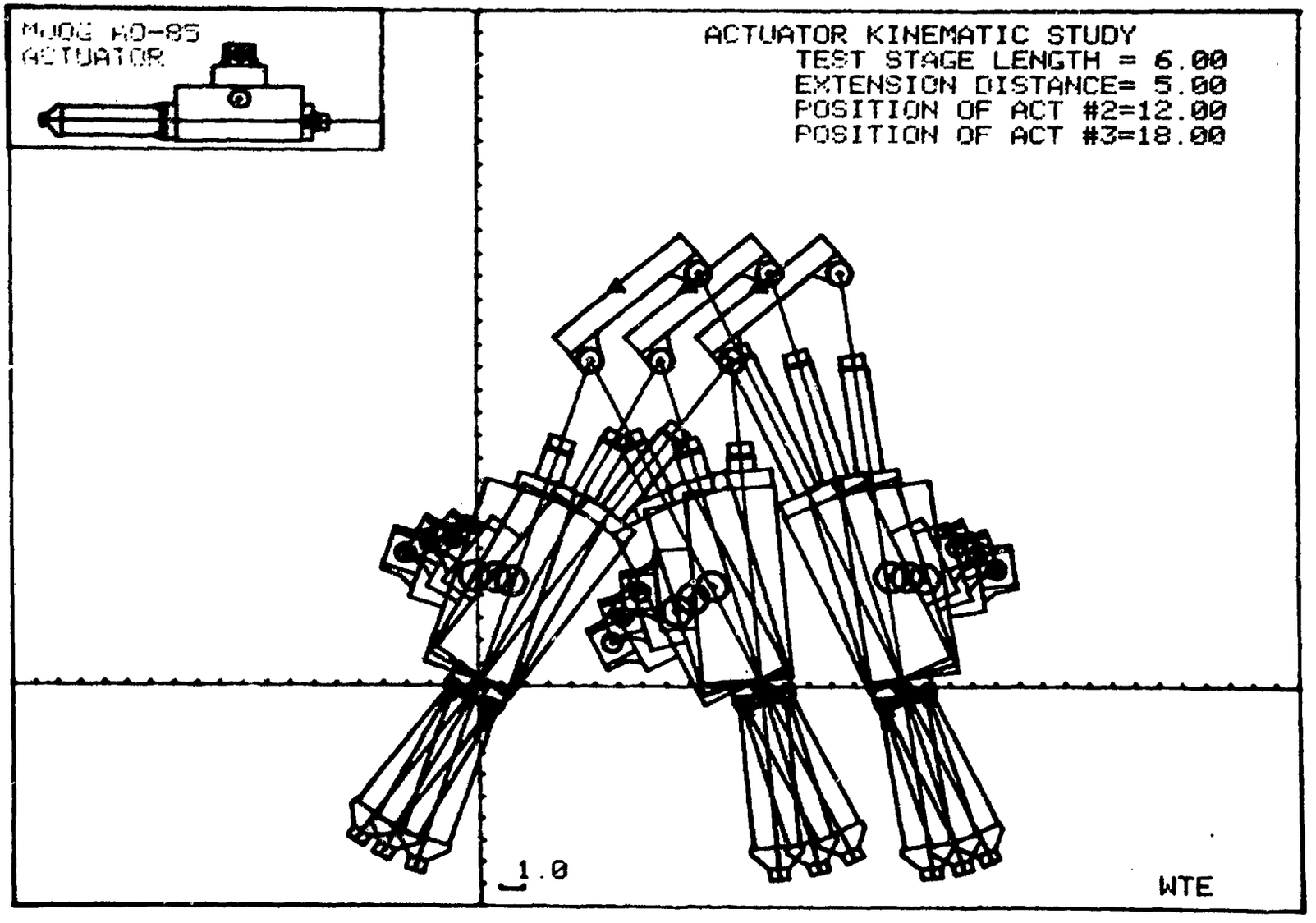
TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-4580.7	4292.3	-3179.0	885.3	7759.7	-5177.6	23800.3
H	1393.6	1487.3	3179.0	-885.3	-4572.7	-602.0	-884.4
M	-4580.7	4292.3	3179.0	-885.3	1401.6	-3406.9	17985.5
2 V	-3392.5	5283.2	-2817.1	1718.7	6209.6	-7001.9	21560.5
H	1711.8	1099.2	2817.1	-1718.7	-4529.0	619.4	527.9
M	-3392.5	5283.2	2817.1	-1718.7	575.4	-3564.6	22012.5

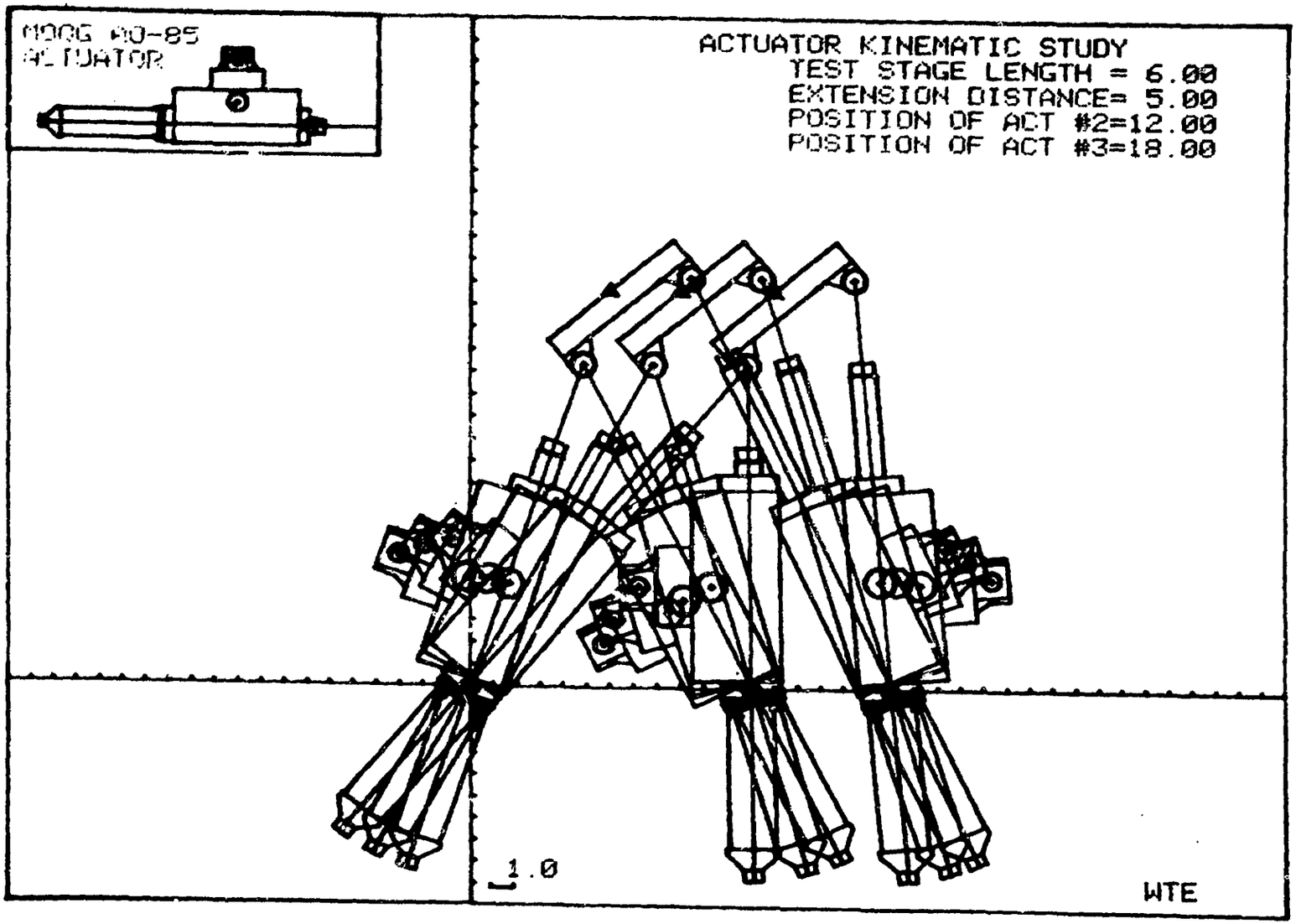
ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-750.0	6232.4	-1886.2	2721.6	2616.2	-8854.1	23800.3
H	2023.6	243.5	1886.2	-2721.6	-3889.8	2478.1	-884.4
M	-750.0	6232.4	1886.2	-2721.6	-1116.2	-3510.8	17985.5
2 V	797.2	6227.8	-1053.3	3127.4	256.1	-8355.2	21580.5
H	2017.8	-258.3	1053.3	-3127.4	-3071.2	3385.7	527.9
M	797.2	6227.8	1053.3	-3127.4	-1859.5	-3100.4	22012.5


MOOG HO-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

+40° NO INT.



KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: MOOG - AC85 - 6 IN STROKE

DATE : 30-JUL-81

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	0.9821	1.8861	5.9587	7.1249	16.2594	0.6981	6.0000	17.6000
P 2	2.1880	0.7863	4.8558	10.1249	16.2594	0.6981	9.0000	17.6000
P 3	3.8210	0.2390	4.2294	13.1249	16.2594	0.6981	12.0000	17.6000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 30-JUL-81

ACTUATOR: M00G - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	3582.5	4928.7	840.3	3191.2	-4422.8	-8119.8	-2527.5
H	2051.8	-1451.4	-840.3	-3191.2	-1211.5	4682.6	2575.5
M	3582.5	4928.7	-840.3	-3191.2	-2742.2	-1737.5	19580.9
2 V	4403.2	4222.1	1286.5	3036.7	-5850.1	-7260.6	-6407.5
H	1743.5	-1818.3	-1286.5	-3036.7	-456.5	4657.0	2652.3
M	4403.2	4222.1	-1286.5	-3036.7	-3116.2	-1183.4	16329.1
3 V	5124.2	3431.0	1745.5	2800.5	-6855.8	-6231.5	-10136.7
H	1308.5	-1854.2	-1745.5	-2800.5	437.1	4754.7	3303.5
M	5124.2	3431.0	-1745.5	-2800.5	-3378.5	-630.5	12782.0

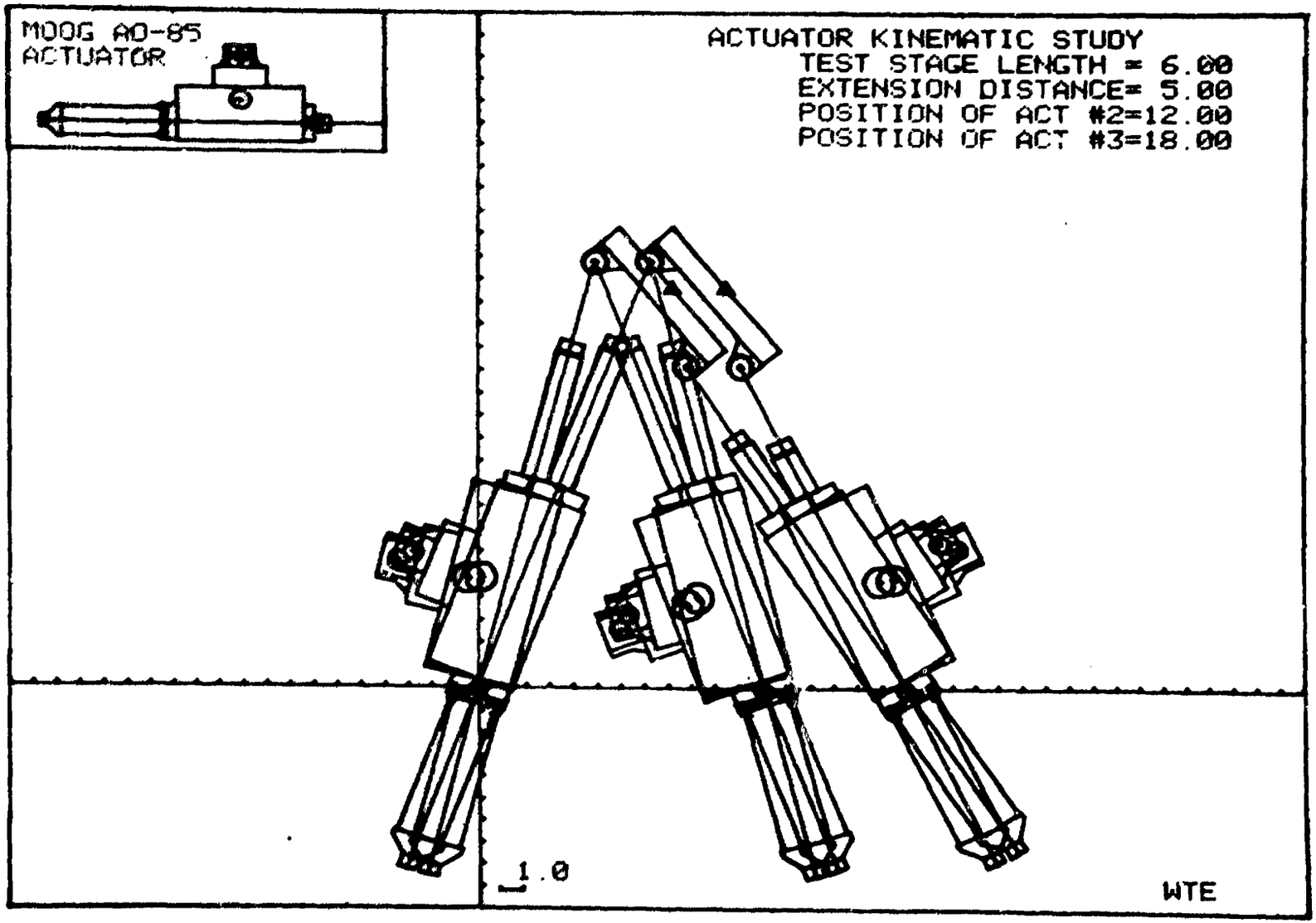
FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 30-JUL-81

ACTUATOR: MOOG - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR		FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1	V	-423.8	6078.4	-1407.6	2984.8	1831.3	-9063.1	-2527.5
	H	2530.4	176.4	1407.6	-2984.8	-3937.9	2808.3	2979.5
	M	-423.8	6078.4	1407.6	-2984.8	-983.8	-3093.6	18560.3
2	V	659.1	6064.6	-967.4	3155.0	308.3	-9219.6	-6407.5
	H	2504.4	-272.2	967.4	-3155.0	-3471.8	3427.2	2962.3
	M	659.1	6064.6	967.4	-3155.0	-1626.5	-2909.6	16329.1
3	V	1719.9	5922.1	-462.9	3267.4	-1257.0	-9189.4	-10130.7
	H	2256.5	-655.9	462.9	-3267.4	-2721.4	3923.3	3303.9
	M	1719.9	5922.1	462.9	-3267.4	-2182.9	-2654.7	12782.0


MOOG AO-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

KINEMATICS OF THE THREE ACTUATOR SYSTEM — DATE : 03-AUG-81

ACTUATOR: MOOR - AOBS - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	5.2701	5.8200	2.7672	6.8594	16.4751	-0.8727	8.2000	17.6000
P 2	5.8777	5.2295	1.8323	9.1594	16.4751	-0.8727	10.5000	17.6000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: M008 - A005 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-5019.4	3788.1	-3275.5	401.3	8294.9	-4189.4	24676.7
H	1207.1	1599.5	3275.5	-401.3	-4482.7	-1190.3	-1842.4
M	-5019.4	3788.1	3275.5	-401.3	1743.9	-3386.9	15619.8
2 V	-4559.0	4321.6	-3201.9	798.8	7770.8	-5120.3	24167.3
H	1375.6	1454.6	3201.9	-798.8	-4577.7	-633.8	-1250.9
M	-4559.0	4321.6	3201.9	-798.8	1367.1	-3522.8	17753.4

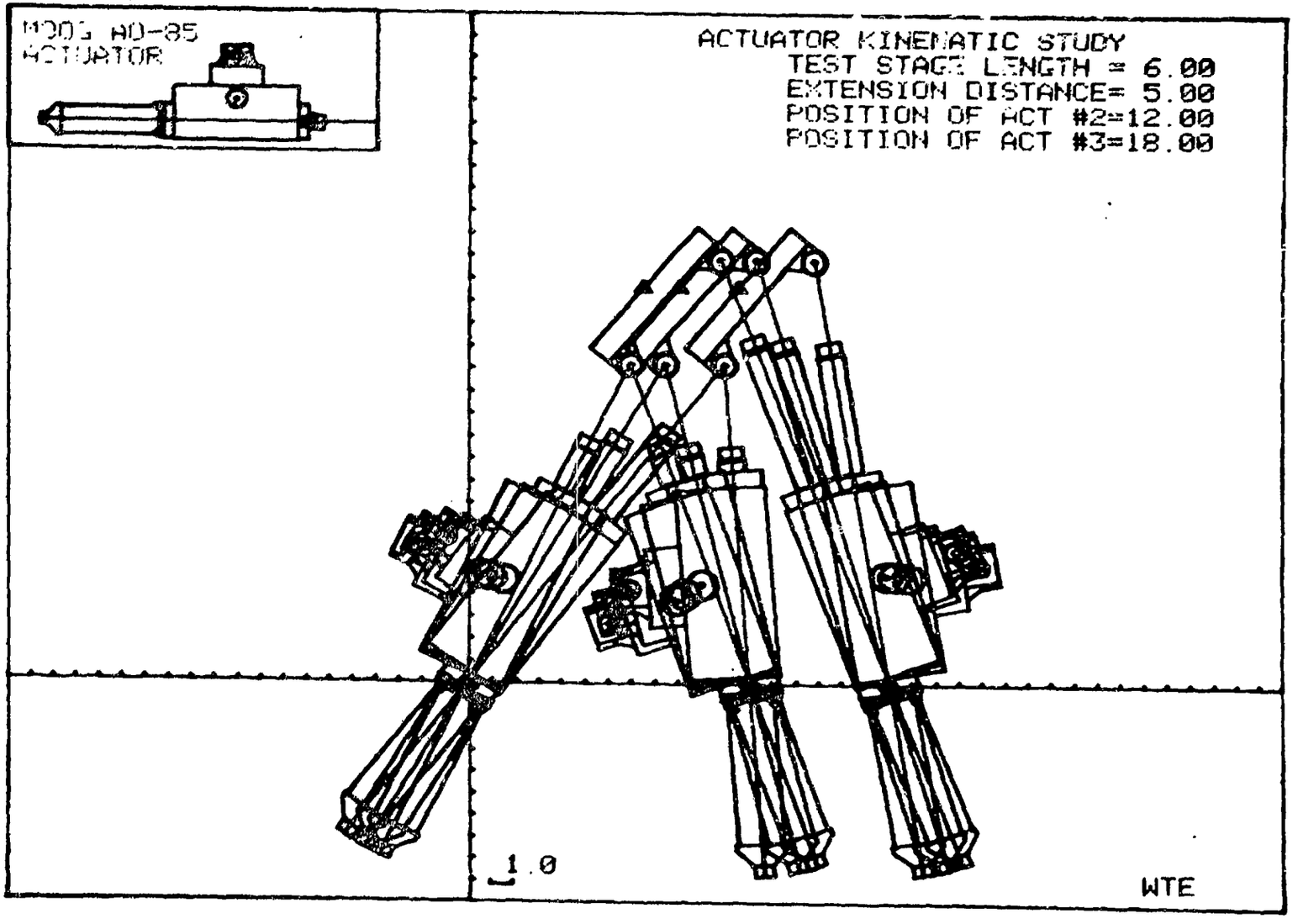
FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 03-AUG-01

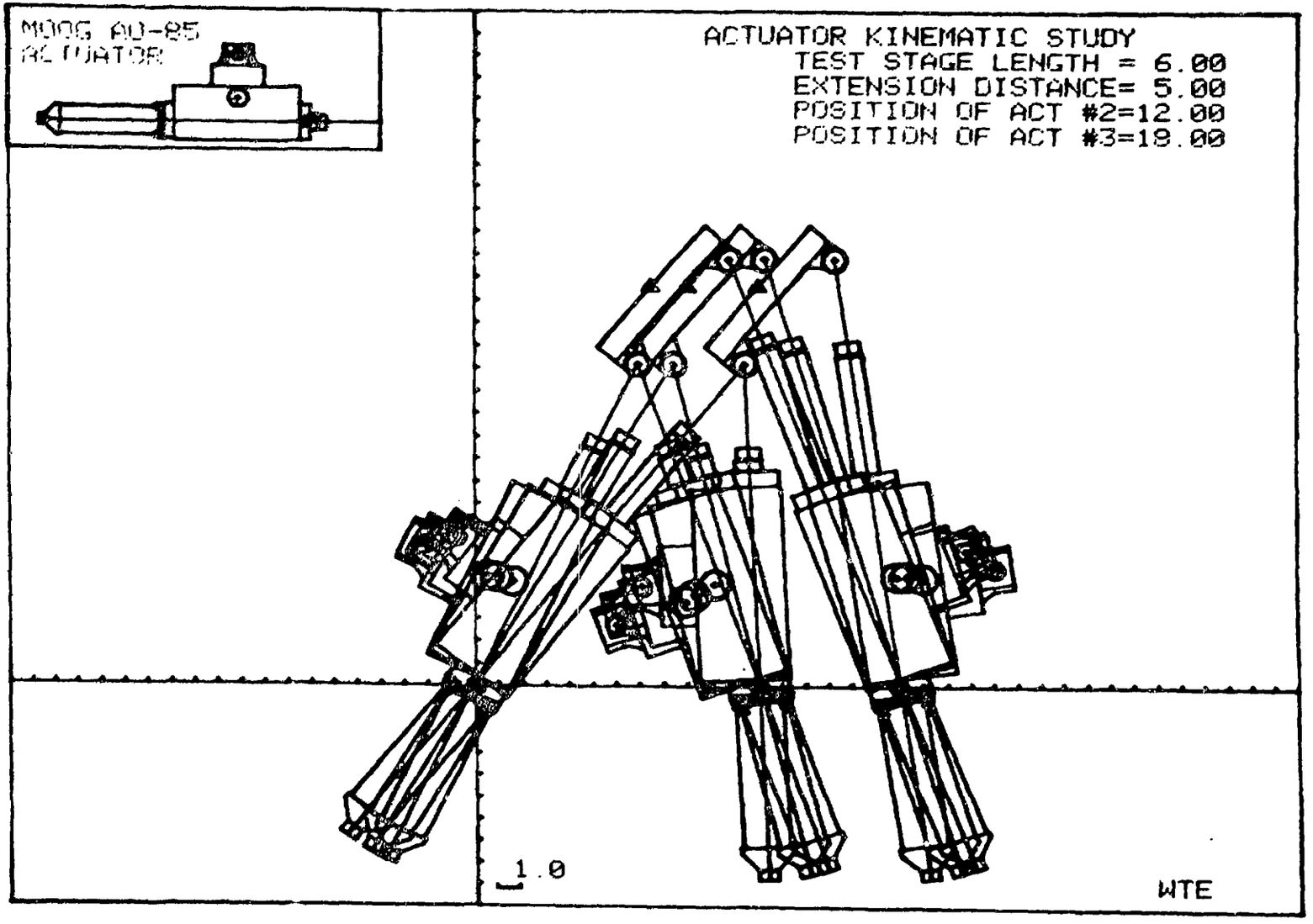
ACTUATOR: MOOG - AQ85 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-324.5	6280.1	-1798.1	2767.1	2122.6	-9047.2	24676.7
H	2001.2	103.4	1798.1	-2767.1	-3799.3	2663.7	-1842.4
M	-324.5	6280.1	1798.1	-2767.1	-1473.5	-3512.9	15619.9
2 V	373.7	6277.9	-1446.2	2966.2	1072.6	-8244.1	24167.3
H	1538.6	-119.0	1446.2	-2966.2	-3444.9	3065.2	-1250.9
M	373.7	6277.9	1446.2	-2966.2	-1819.9	-3311.7	17753.4


MOOG AO-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE


MOOG AO-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=19.00
1.0
WTE

KINEMATICS OF THE THREE ACTUATOR SYSTEM DATE : 30-JUL-81
ACTUATOR: M000 - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 9.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	1.8323	0.5223	5.8777	8.8403	16.4751	0.8727	7.5000	17.5000
P 2	2.3445	0.4839	5.4886	10.3405	16.4751	0.8727	9.0000	17.5000
P 3	3.7503	0.0787	4.9093	12.8403	16.4751	0.8727	11.5000	17.5000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 30-JUL-81

ACTUATOR: MOOG - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR		FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1	V	4864.7	3649.2	1596.6	2888.1	-6461.3	-6537.3	-9023.9
	H	1539.0	-2051.6	-1596.6	-2888.1	57.6	4939.7	2610.0
	M	4864.7	3649.2	-1596.6	-2888.1	-3258.2	-761.1	13892.5
2	V	5186.8	3210.8	1798.5	2768.9	-6985.2	-5977.7	-10852.3
	H	1326.2	-2142.3	-1798.5	-2768.9	472.3	4908.2	2700.0
	M	5186.8	3210.8	-1798.5	-2768.9	-3388.3	-443.8	12908.5
3	V	5855.3	2447.4	2131.5	2519.2	-7783.9	-4950.8	-12842.8
	H	638.8	-2155.4	-2131.5	-2519.2	1192.7	4698.3	3138.8
	M	5855.3	2447.4	-2131.5	-2519.2	-3523.8	71.9	8733.2

FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 30-JUL-81

ACTUATOR: MOOG - A085 - 6 IN STROKE

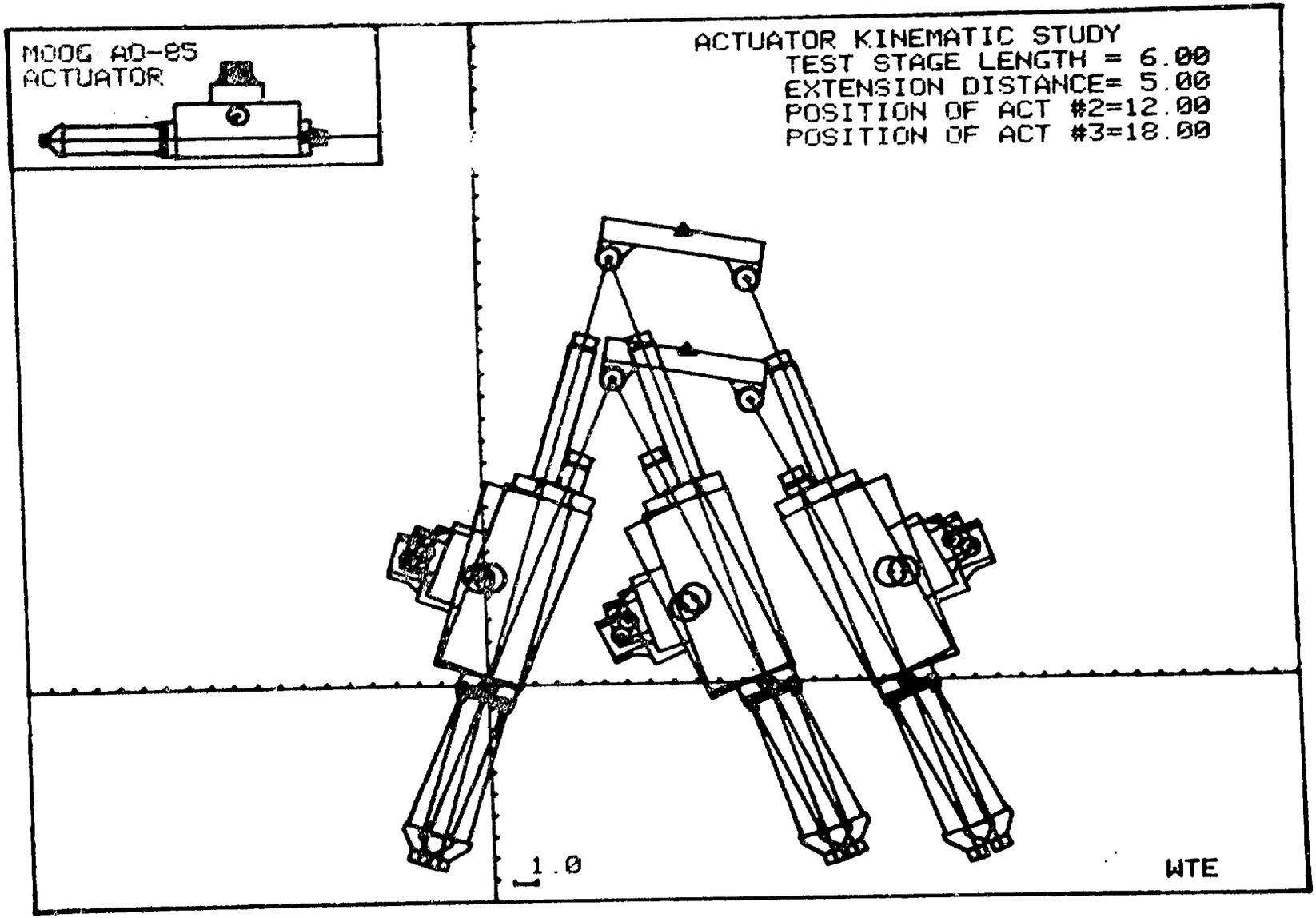
ACTUATOR PIVOT POSITION:

ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE

LENGTH: 9.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	331.5	6072.3	-1186.1	3075.5	854.5	-9151.7	-9023.9
H	2560.9	-139.8	1186.1	-3075.5	-3747.1	3219.3	2610.0
M	331.5	6072.3	1186.1	-3075.5	-1517.7	-2992.8	13892.5
2 V	874.4	6037.1	-963.5	3156.2	88.1	-9193.3	-10852.3
H	2493.8	-361.2	963.5	-3156.2	-3457.1	3517.4	2700.0
M	874.4	6037.1	963.5	-3156.2	-1837.8	-2880.8	12003.5
3 V	1780.4	5905.4	-559.7	3252.2	-1220.3	-9157.8	-13842.3
H	2255.3	-675.3	559.7	-3252.2	-2525.3	3827.5	3136.8
M	1780.4	5905.4	559.7	-3252.2	-2220.1	-2853.2	8733.2


MOOG AO-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: MOOG - A085 - 6 IN STROKE

DATE : 03-AUG-81

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	5.8020	5.9568	4.9955	8.6961	18.5766	-0.1745	9.0000	20.3000
P 2	0.7123	0.9155	0.0151	8.6961	13.1766	-0.1745	9.0000	14.9000

FORCES ON TEST STAGE (LOCAL COORDINATES)

DATE : 03-AUG-81

ACTUATOR: M008 - A005 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 8.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-1163.7	6187.1	-1618.7	2875.7	2708.4	-9062.8	14613.7
H	1843.5	397.4	1618.7	-2875.7	-3582.2	2508.3	3485.5
N	-1163.7	6187.1	1618.7	-2875.7	-449.1	-3311.3	28402.5
2 V	-1143.9	5336.5	-1569.5	2847.8	3113.4	-8384.3	15314.7
H	2599.6	500.9	1969.5	-2847.8	-4569.2	2146.8	1450.1
N	-1143.9	5336.5	1569.5	-2847.8	-825.7	-3299.7	24306.1

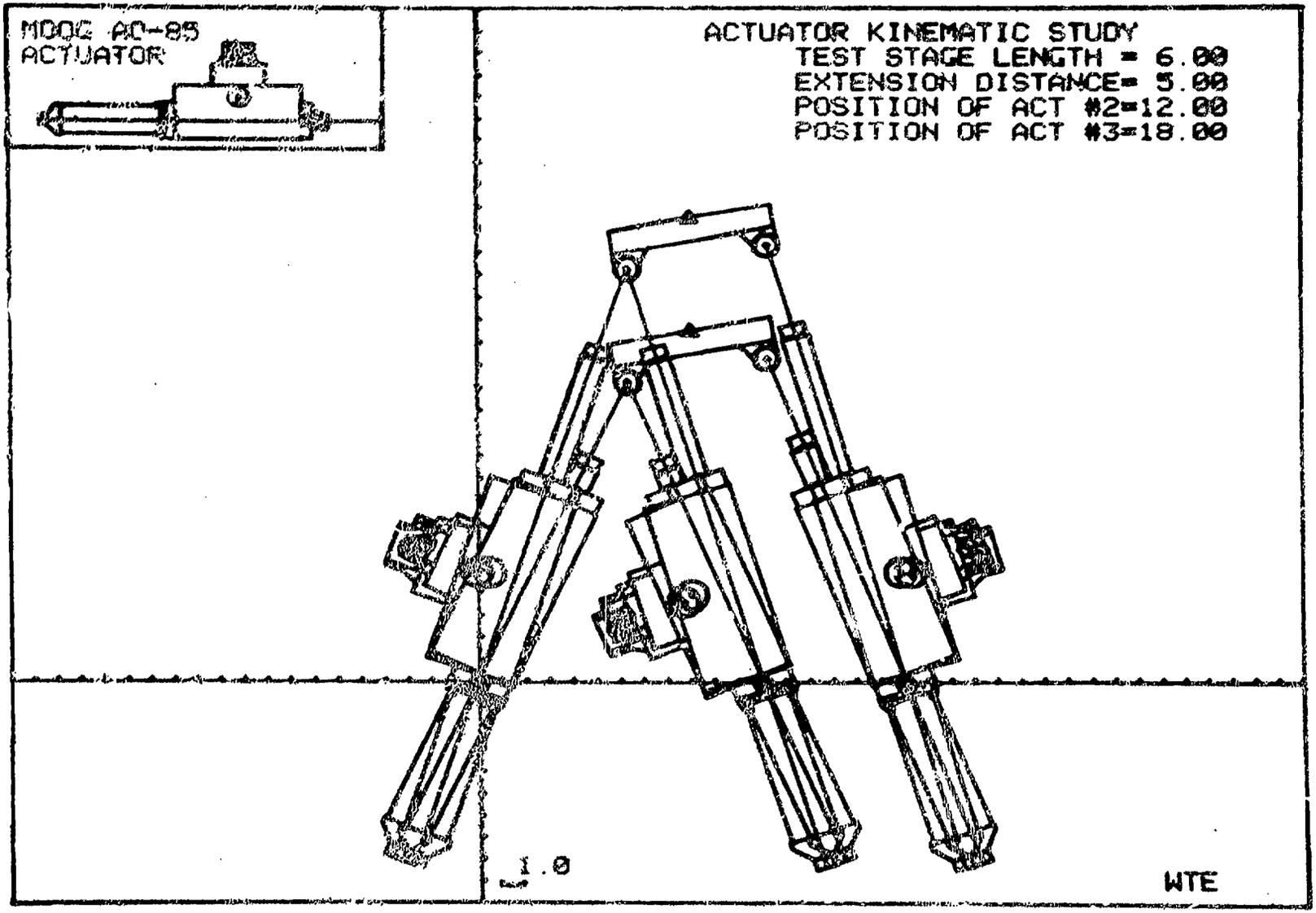
FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: MOOG - ABOS - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-77.5	8256.2	-1084.8	3113.1	1172.3	-9408.3	14813.7
H	1977.8	24.3	1084.8	-3113.1	-3072.5	3088.8	3455.5
M	-77.5	8288.2	1084.8	-3113.1	-1017.2	-3183.1	28402.5
2 V	-85.6	8045.0	-1479.8	2949.6	1575.5	-8854.6	15314.7
H	2647.1	41.9	1479.8	-2949.6	-4127.0	2907.7	1450.1
M	-85.6	8045.0	1479.8	-2949.6	-1384.2	-3955.4	24308.1


MDOC AC-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

KINEMATICS OF THE THREE ACTUATOR SYSTEM DATE : 30-JUL-81
ACTUATOR: MOOG - AC85 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 5.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	5.1883	4.5701	5.8536	9.3039	18.7765	0.1745	9.0000	20.5000
P 2	0.5575	0.2657	1.2873	9.3039	13.7765	0.1745	9.0000	15.5000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 30-JUL-81

ACTUATOR: MODS - A065 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	1195.3	6155.2	-377.9	3278.3	-817.9	-9433.9	7199.7
H	2022.3	-392.7	377.9	-3278.3	-2355.9	3671.1	4457.0
M	1195.3	6155.2	377.3	-3278.3	-1572.9	-2876.9	25548.2
2 V	1173.5	5857.7	-679.3	3229.3	-484.2	-8127.0	7140.4
H	2655.0	-530.5	679.3	-3229.3	-3347.3	3750.2	2237.9
M	1173.5	5857.7	679.3	-3229.3	-1852.8	-2655.4	24138.3

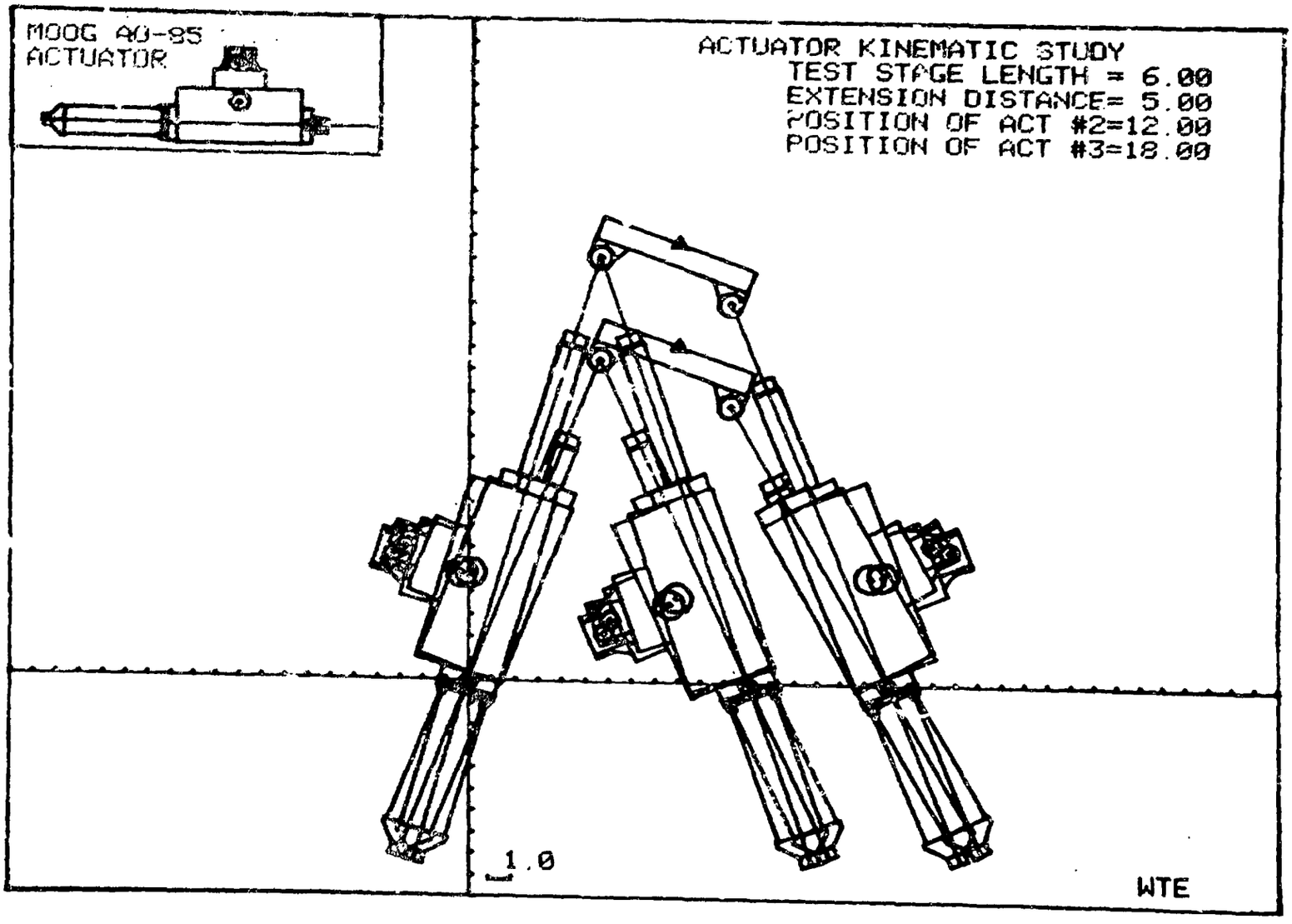
FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 30-JUL-81

ACTUATOR: MODS - ACB5 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 5.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FXZ (LBS)	FYZ (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	108.3	8259.3	-941.1	3163.0	832.8	-8432.3	7195.7
H	2059.8	-55.5	941.1	-3163.0	-3000.8	3139.6	4457.0
M	108.3	8269.3	941.1	-3163.0	-1049.4	-3106.3	25548.2
2 V	131.6	8011.9	-1229.8	3062.3	1088.2	-8074.2	7140.4
H	2719.6	-55.5	1229.8	-3062.3	-3949.4	3121.6	2237.3
M	131.6	8011.9	1229.8	-3062.3	-1331.3	-2949.3	24138.3


MOOG A0-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: H00G - A0B5 - 6 IN STROKE

DATE : 03-AUG-81

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 8.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	5.7414	5.8515	4.1853	8.4015	18.0535	-0.3491	9.0000	15.7000
P 2	1.3903	1.8583	0.0181	8.4015	13.4535	-0.3491	9.0000	15.1000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: MOOG - AO85 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-2270.9	5872.6	-2155.6	2463.6	4466.5	-8336.2	18043.1
H	1845.8	713.7	2155.6	-2463.6	-4041.3	1749.8	2459.7
M	-2270.9	5872.6	2155.6	-2463.6	75.3	-3408.9	23140.3
2 V	-2226.0	5877.2	-2475.7	2181.9	4701.7	-7859.1	18713.9
H	2350.5	921.6	2475.7	-2181.9	-4826.2	1260.3	884.7
M	-2226.0	5877.2	2475.7	-2181.9	-249.7	-3495.3	23140.4

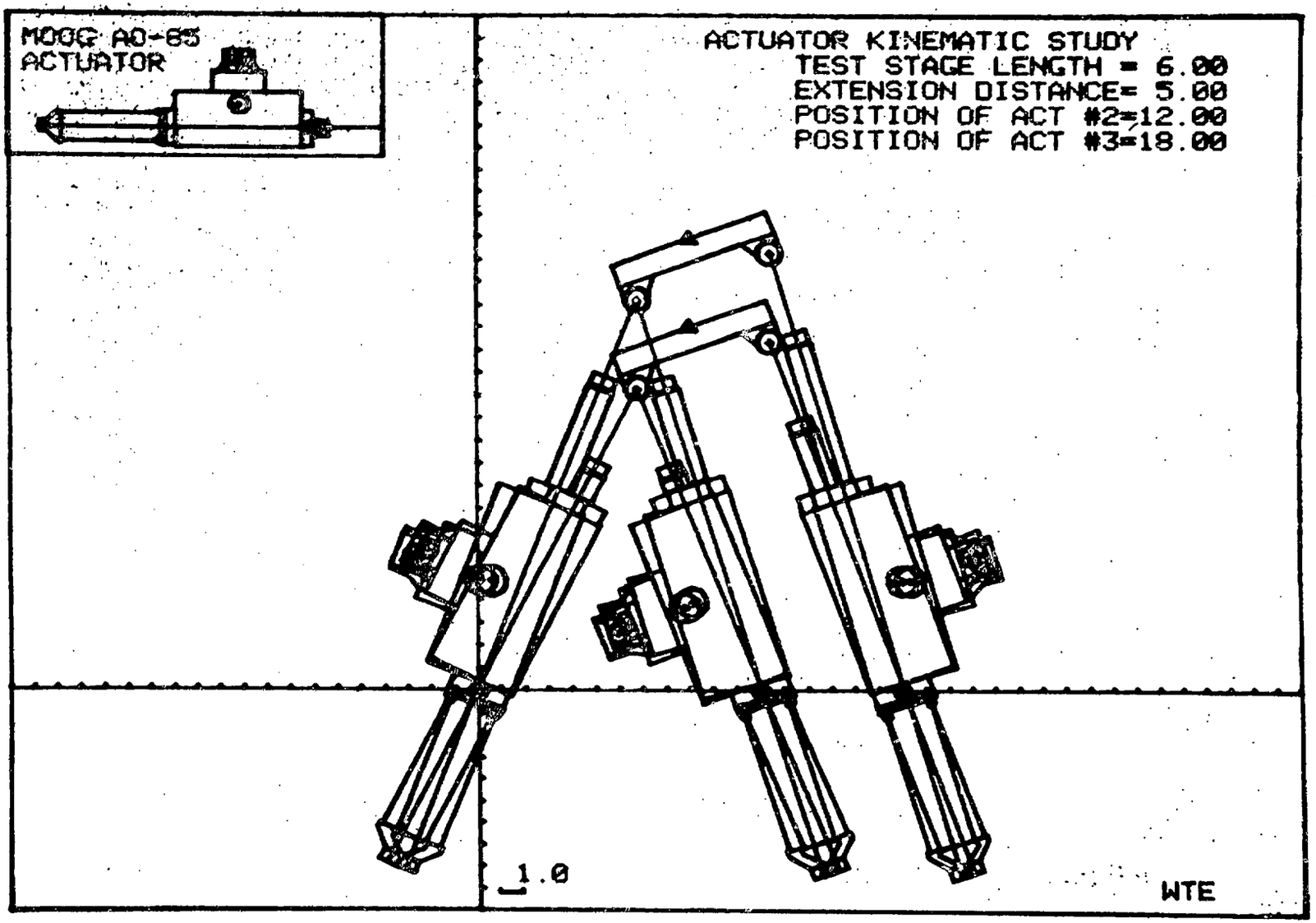
FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: MOOG - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-125.4	6295.1	-1220.6	3068.0	1345.9	-8361.1	18043.1
H	1978.8	39.4	1220.8	-3068.0	-3199.1	3026.6	2459.7
M	-125.4	6295.1	1220.6	-3066.0	-1095.2	-3229.1	25140.3
2 V	-150.1	6096.2	-1580.2	2897.1	1730.2	-8993.2	18713.9
H	2524.0	82.1	1580.2	-2897.1	-4104.1	2835.0	864.7
M	-150.1	6096.2	1580.2	-2897.1	-1430.1	-3199.1	23140.4


MOOG A0-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

+20°

KINEMATICS OF THE THREE ACTUATOR SYSTEM DATE : 30-JUL-81
ACTUATOR: MOD3 - AC85 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	4.3753	3.8639	5.8334	9.5985	18.2555	0.3491	9.0000	15.8000
P 2	0.8145	0.1753	2.2233	9.5985	14.3555	0.3491	9.0000	16.0000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 30-JUL-81

ACTUATOR: MODE - A085 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 5.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	2366.7	5767.4	221.8	3292.5	-2588.4	-9059.8	7894.8
H	2004.5	-622.7	-221.8	-3292.5	-1783.0	4115.2	4355.8
M	2936.7	5767.4	-221.8	-3292.5	-2144.8	-2474.9	23423.3
2 V	2331.8	5551.4	3.0	3300.0	-2334.8	-9851.4	2688.0
H	2451.8	-1046.7	-3.0	-3300.0	-2485.7	4345.7	2404.7
M	2331.8	5551.4	-3.0	-3300.0	-2328.8	-2251.4	22476.7

FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 30-JUL-81

ACTUATOR: MCCI - AC85 - 6 IN STROKE

ACTUATOR PIVOT POSITION:

ACTUATOR #1 (0.00, 0.00)

ACTUATOR #2 (12.00, 0.00)

ACTUATOR #3 (18.00, 0.00)

TEST STAGE

LENGTH: 6.000

HEIGHT: 1.750

ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	251.4	5229.0	-917.7	3168.8	666.4	-8398.8	2854.6
H	2155.2	-87.4	917.7	-3168.8	-3083.0	3257.2	4289.3
M	251.4	5229.0	917.7	-3168.8	-1169.1	-8398.8	23425.3
2 V	292.8	6014.2	-1125.8	3102.0	838.2	-9116.2	2558.0
H	2392.5	-101.3	1125.8	-3102.0	-3825.3	3223.3	2404.7
M	292.8	6014.2	1125.8	-3102.0	-1416.4	-9512.1	22478.7

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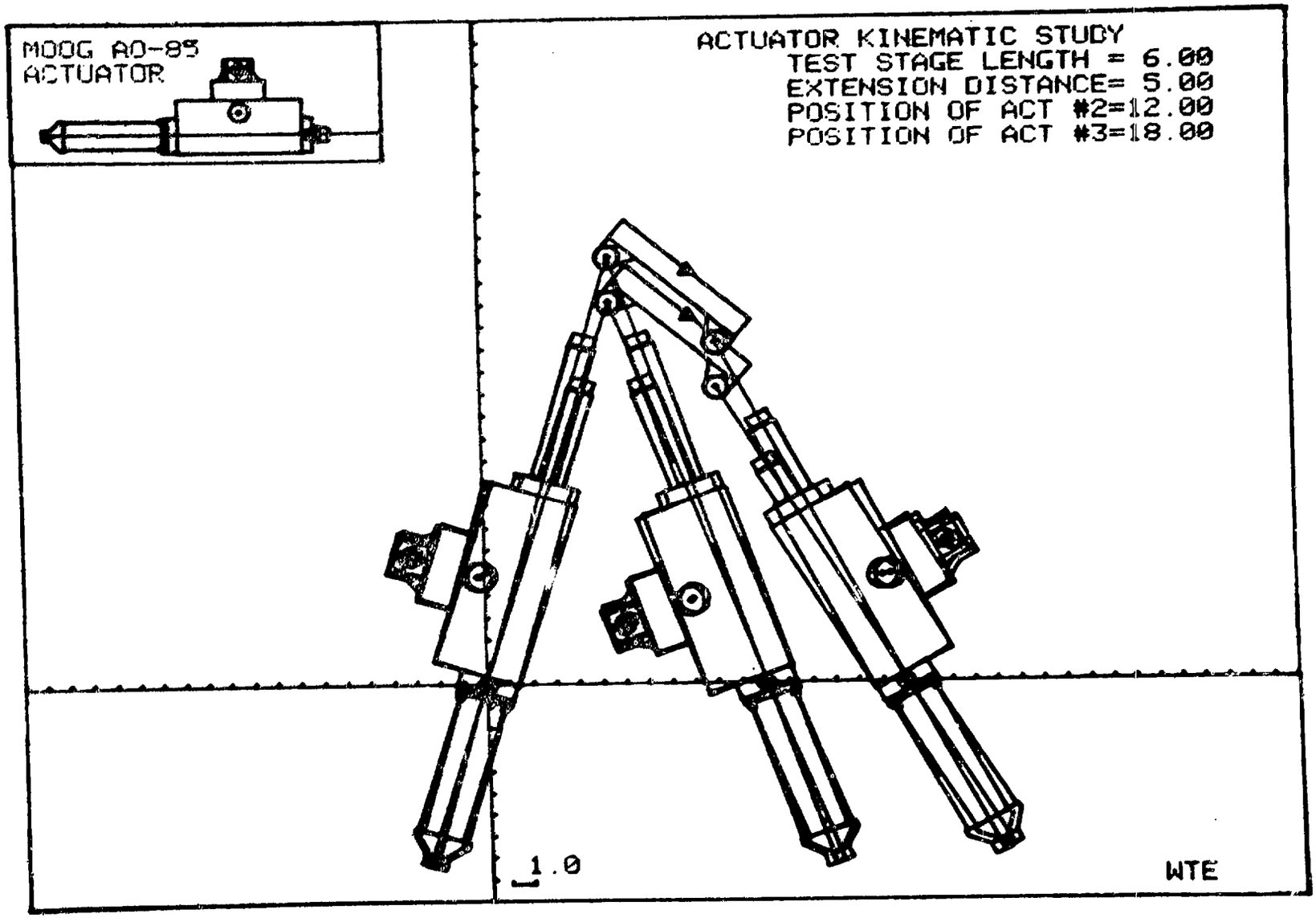

MOOG AO-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: MOOG - 4005 - 8 IN STROKE

DATE : 03-AUG-01

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	5.7459	5.0005	2.0043	7.8751	17.1594	-0.8981	5.0000	18.5000
P 2	3.8348	4.1151	1.2327	7.8751	15.1594	-0.8981	9.0000	18.5000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: MOOG - AQBS - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FXZ (LBS)	FYZ (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-4143.8	4740.8	-3042.1	1278.0	7185.8	-8019.8	22960.8
H	1489.5	1302.0	3042.1	-1278.0	-4531.6	-23.0	-187.6
M	-4143.8	4740.8	3042.1	-1278.0	1101.7	-3461.9	19987.3
2 V	-4107.2	4691.3	-3112.8	1085.8	7220.0	-5777.1	23391.4
H	1842.8	1441.4	3112.8	-1085.8	-4755.6	-345.6	-710.8
M	-4107.2	4691.3	3112.8	-1085.8	994.4	-3585.5	19071.5

FORCES ON TEST STAGE (GLOBAL COORDINATES)

DATE : 03-AUG-81

ACTUATOR: MOOG - A083 - 6 IN STROKE

ACTUATOR PIVOT POSITION:

ACTUATOR #1 (0.00, 0.00)

ACTUATOR #2 (12.00, 0.00)

ACTUATOR #3 (18.00, 0.00)

TEST STAGE

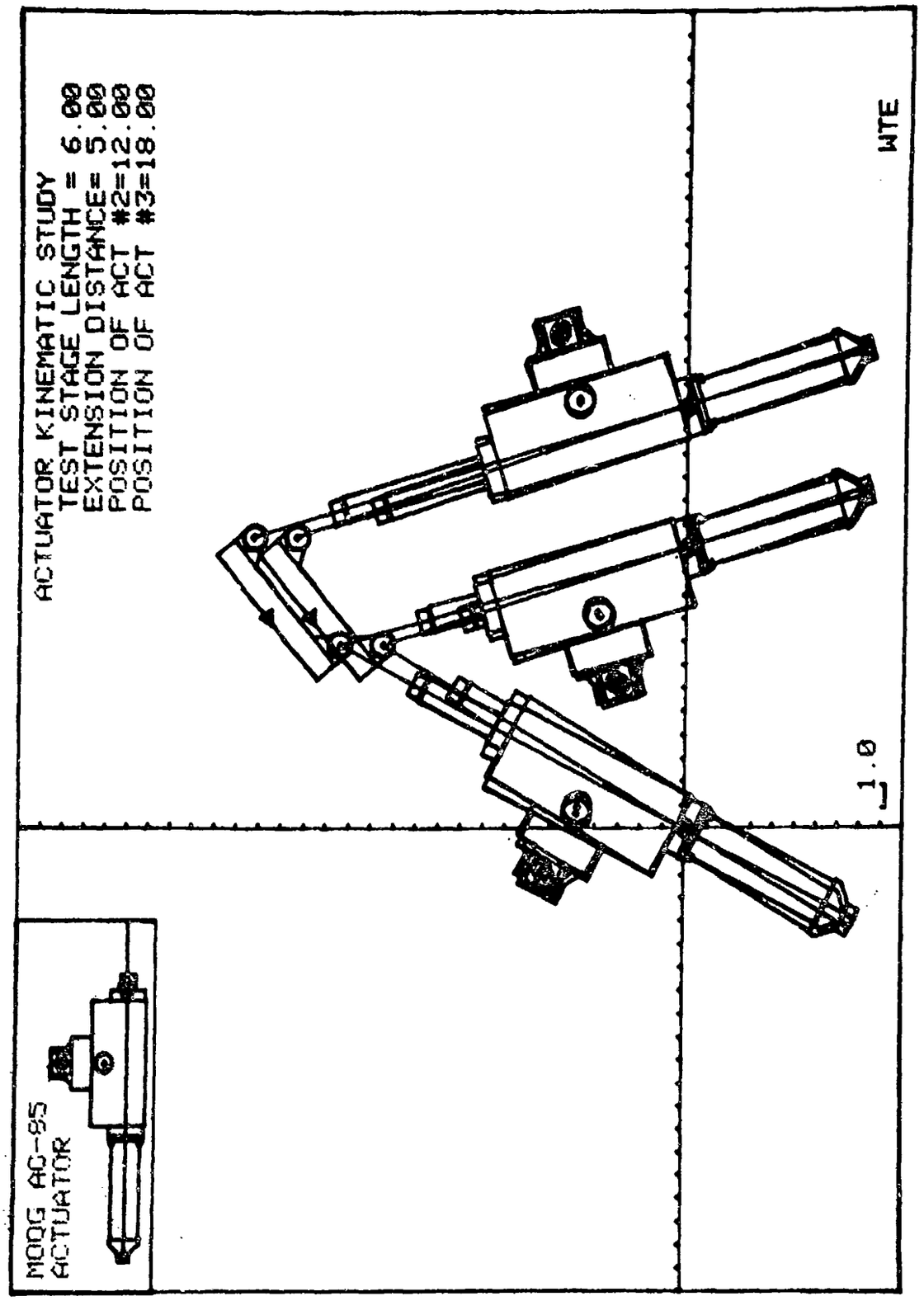
LENGTH: 6.000

WEIGHT: 1.750

ACTUATOR EXTENSION: 5.000

CASE/PAIR		FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FYZ (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1	V	-127.0	6295.2	-1508.3	2935.1	1635.2	-8230.4	22960.8
	H	1977.8	39.9	1508.3	-2835.1	-3436.2	2893.3	-187.6
	H	-127.0	6295.2	1508.3	-2935.1	-1389.3	-3360.1	19987.3
2	V	-137.2	6226.1	-1680.1	2840.3	1817.4	-8066.4	23391.4
	H	2185.0	48.2	1680.1	-2840.3	-3685.1	2782.1	-710.8
	H	-137.2	6226.1	1680.1	-2840.3	-1542.9	-3385.9	19071.5

+40° ≥


ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
WTE
1.0
MOOG AC-85
ACTUATOR

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: MOOG - 4085 - 6 IN STROKE

DATE : 03-AUG-81

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	3.1825	1.8454	5.9379	10.1249	17.3594	0.6981	5.0000	18.7000
P 2	1.4816	0.0200	4.1203	10.1249	15.4594	0.6981	5.0000	16.8000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: MODU - A085 - 0 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FXZ (LBS)	FYZ (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	4423.0	4289.1	1335.5	3017.7	-5758.5	-7306.7	-6263.2
H	1847.6	-1699.0	-1335.5	-3017.7	-312.1	4716.7	3409.8
M	4423.0	4289.1	-1335.5	-3017.7	-3087.4	-1271.4	16517.2
2 V	4383.8	4167.0	1247.8	3055.0	-5831.6	-7222.0	-6519.4
H	1820.0	-1914.7	-1247.8	-3055.0	-572.2	4989.7	2419.7
M	4383.8	4167.0	-1247.8	-3055.0	-3136.1	-1112.0	16177.9

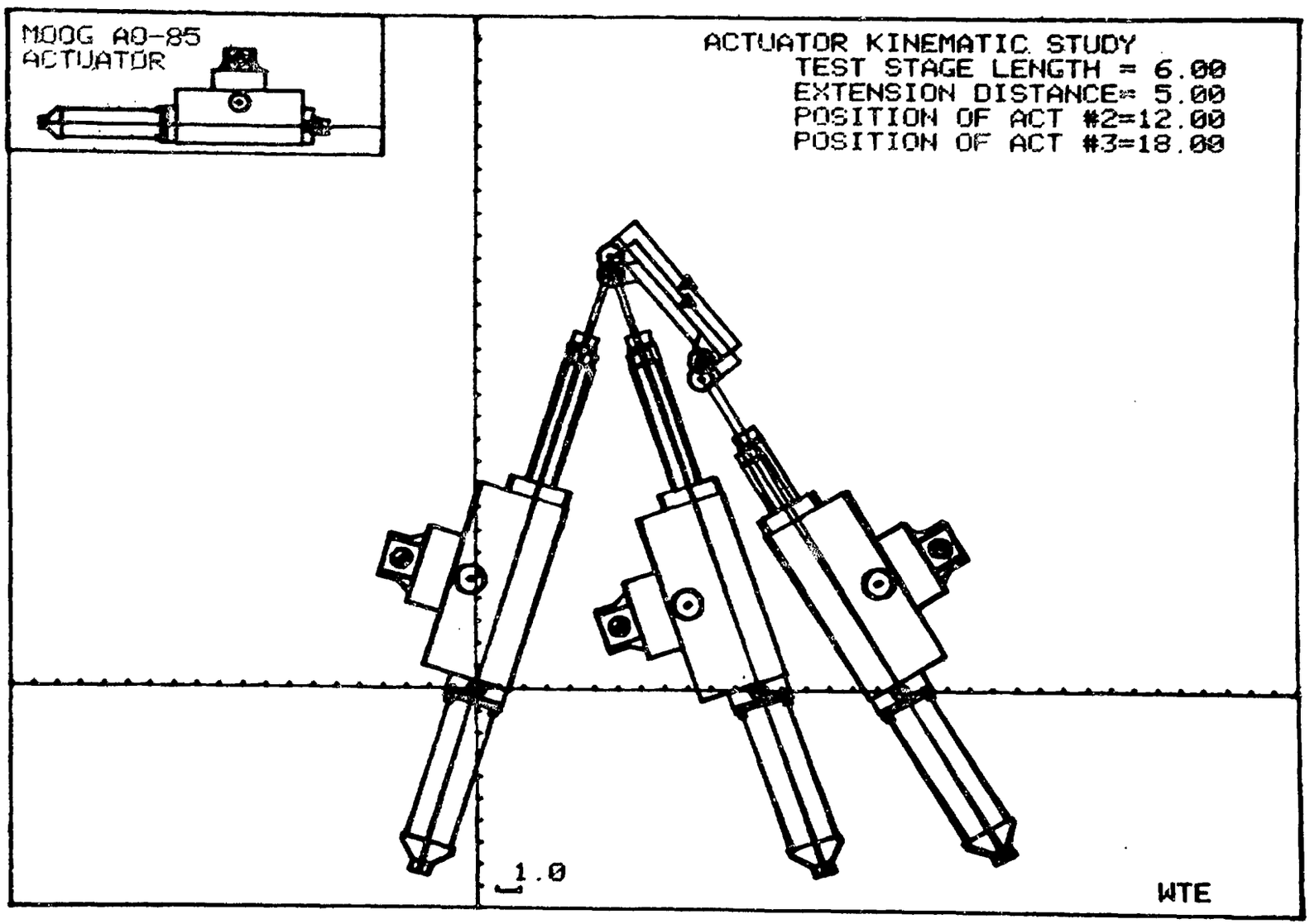
FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: MOOG - AC65 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	631.2	6128.6	-916.6	3170.1	285.4	-9298.8	-6263.2
H	2354.3	-242.5	916.6	-3170.1	-3270.9	3412.6	3409.9
M	631.2	6128.6	916.6	-3170.1	-1547.9	-2858.5	16517.2
2 V	679.7	6010.0	-1007.9	3142.3	328.1	-9152.3	-6519.4
H	2624.9	-296.9	1007.9	-3142.3	-3832.8	3439.2	2418.7
M	679.7	6010.0	1007.9	-3142.3	-1697.6	-2867.7	16177.9


MOOG A0-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: M30G - A08S - 6 IN STROKE

DATE : 03-AUG-91

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 8.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (DEG)	STG POS X	STG POS Y
P 1	5.8715	6.0321	2.6902	7.6594	16.8751	-0.8727	9.0000	18.0000
P 2	5.1083	5.2733	2.0022	7.6594	16.0751	-0.8727	9.0000	17.2000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: MOOG - AO85 - 8 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-4876.6	3986.8	-3249.8	573.7	8126.3	-4560.6	24480.6
H	1247.4	1525.8	3249.8	-573.7	-4497.2	-852.1	-1571.7
M	-4876.6	3986.8	3249.8	-573.7	1628.8	-3413.2	18528.8
2 V	-4859.2	3968.9	-3263.0	493.0	8122.1	-4461.9	24641.6
H	1295.8	1586.5	3263.0	-493.0	-4558.8	-1093.5	-1739.5
M	-4859.2	3968.9	3263.0	-493.0	1596.2	-3476.0	18178.0

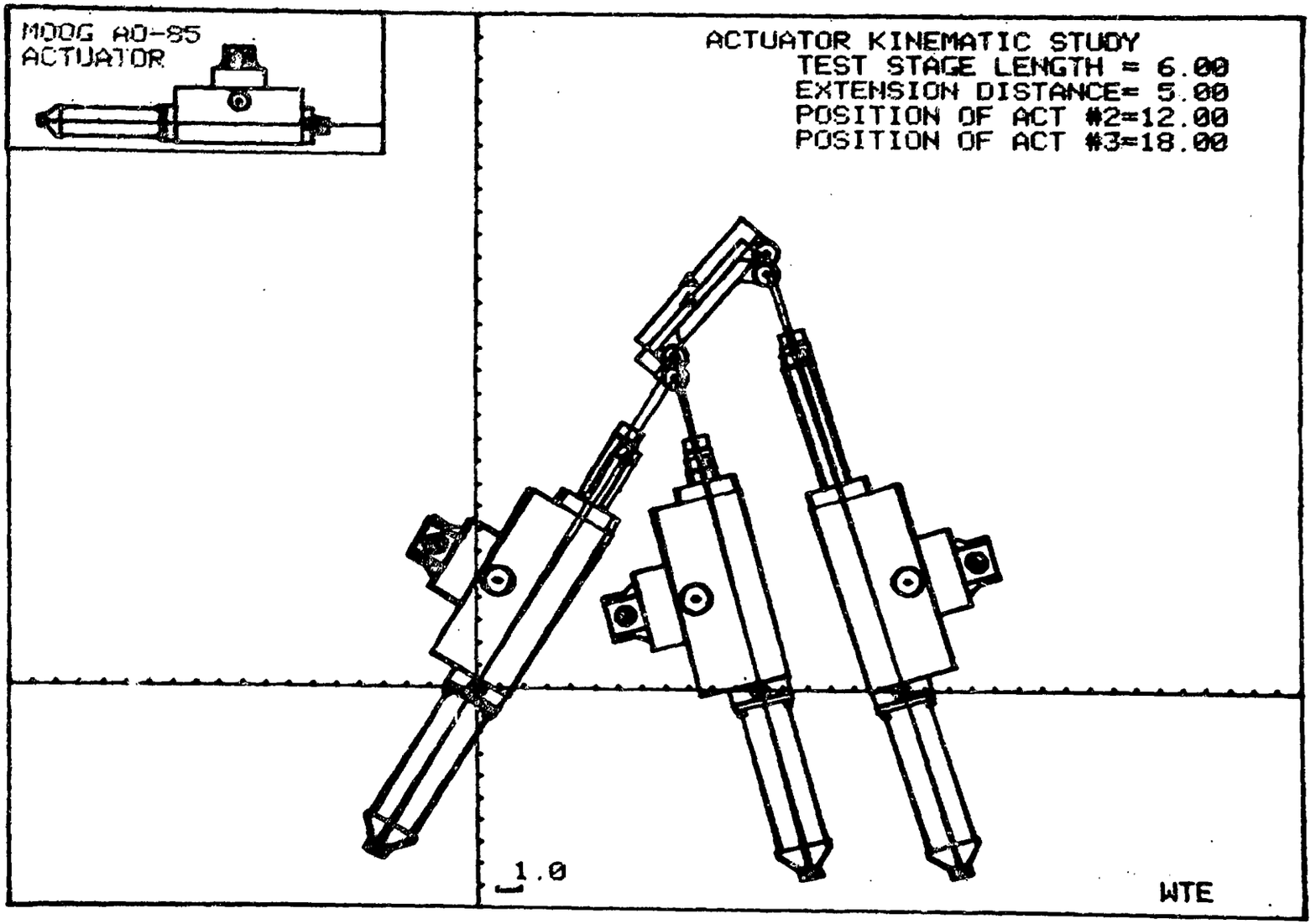
FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: MOOB - AOO5 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	-80.5	6298.4	-1849.4	2858.2	1729.9	-9156.6	24460.6
H	1870.6	25.2	1849.4	-2858.2	-3820.1	2833.0	-1571.7
M	-80.5	6298.4	1849.4	-2858.2	-1569.0	-3440.2	16528.8
2 V	-83.0	6273.5	-1719.7	2816.5	1802.7	-9090.0	24841.6
H	2048.3	27.1	1719.7	-2816.5	-3768.0	2789.4	-1739.5
M	-83.0	6273.5	1719.7	-2816.5	-1638.8	-3457.0	16179.0


MOOG AO-85
ACTUATOR
ACTUATOR KINEMATIC STUDY
TEST STAGE LENGTH = 6.00
EXTENSION DISTANCE= 5.00
POSITION OF ACT #2=12.00
POSITION OF ACT #3=18.00
1.0
WTE

.KINEMATICS OF THE THREE ACTUATOR SYSTEM
ACTUATOR: MOOS - AOOS - 6 IN STROKE

DATE : 03-AUG-81

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE	PL1 (IN)	PL2 (IN)	PL3 (IN)	REF PNT X	REF PNT Y	THETA (RAD)	STG POS X	STG POS Y
P 1	2.7768	0.9691	5.9873	10.3408	16.8751	0.8727	9.0000	18.1000
P 2	2.0022	0.0965	5.1063	10.3408	16.0751	0.8727	9.0000	17.2000

FORCES ON TEST STAGE (LOCAL COORDINATES) DATE : 03-AUG-01
ACTUATOR: M000 - A005 - 6 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	5200.0	3244.1	1818.5	2753.7	-7018.5	-5997.8	-10811.3
H	1296.1	-2077.3	-1818.5	-2753.7	522.4	4831.3	2942.8
M	5200.0	3244.1	-1818.5	-2753.7	-3381.5	-490.3	12075.8
2 V	5174.8	3182.8	1781.8	2777.7	-6956.4	-5960.5	-10658.4
H	1351.2	-2186.8	-1781.8	-2777.7	430.4	4974.5	2498.0
M	5174.8	3182.8	-1781.8	-2777.7	-3393.1	-405.1	11943.7

. FORCES ON TEST STAGE (GLOBAL COORDINATES) DATE : 03-AUG-81

ACTUATOR: MRRS - ARRS - 8 IN STROKE

ACTUATOR PIVOT POSITION:
ACTUATOR #1 (0.00, 0.00)
ACTUATOR #2 (12.00, 0.00)
ACTUATOR #3 (18.00, 0.00)

TEST STAGE
LENGTH: 6.000
HEIGHT: 1.750
ACTUATOR EXTENSION: 5.000

CASE/DIR	FX1 (LBS)	FY1 (LBS)	FX2 (LBS)	FY2 (LBS)	FRX (LBS)	FRY (LBS)	MOMENT (IN-LBS)
1 V	857.4	6068.7	-940.8	3163.1	83.2	-9231.8	-10811.3
H	2424.8	-342.5	940.8	-3163.1	-3365.2	3505.7	2842.8
M	857.4	6068.7	940.8	-3163.1	-1798.0	-2505.8	12075.8
2 V	868.1	6010.0	-882.7	3150.3	94.6	-9160.3	-10658.4
H	2551.4	-377.0	882.7	-3150.3	-3534.0	3527.3	2496.0
M	868.1	6010.0	882.7	-3150.3	-1670.7	-2659.7	11843.7